SERVICE MANUAL

SORVALL® RC-5C and RC-5C PLUS

Thermo Electron Corporation
Asheville, North Carolina
U.S.A.

SORVALL®

Thermo
ELECTRON CORPORATION

PN 50853-3
Issued May 2006

RC-5C *Plus*

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RC-5C *Plus*
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1.0 Operation

SORVALL®

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RC-5C PLUS

OPERATING INSTRUCTIONS

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PN 74559-9

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SORVALL® RC-5C PLUS

Superspeed Centrifuge

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This manual is a guide for use of the

SORVALL® RC-5C PLUS Superspeed Centrifuge

Data herein has been verified and is believed adequate for the intended use of the centrifuge. Because failure to follow the recommendations set forth in this manual could produce personal injury or property damage, always follow the recommendations set forth herein. Thermo does not guarantee results and assumes no obligation for the performance of products that are not used in accordance with the instructions provided. This publication is not a license to operate under, nor a recommendation to infringe upon, any process patents.

Publications prior to the Issue Date of this manual may contain data in apparent conflict with that provided herein. Please consider all data in this manual to be the most curent.

WARNING, ***CAUTION***, and ***NOTE*** within the text of this manual are used to emphasize important and critical instructions.

> ***WARNING*** informs the operator of a hazard or an unsafe practice that could result in personal injury, affect the operator's health, or contaminate the environment.
>
> ***CAUTION*** informs the operator of an unsafe practice that could result in damage of equipment.
>
> ***NOTE*** highlights essential information.

CAUTION and ***WARNING*** are accompanied by a hazard symbol ⚠ and appear in the left sidebar near the information they correspond to.

Important Safety Information

Certain potentially dangerous conditions are inherent to the use of all centrifuges. To ensure safe operation of this centrifuge, anyone using it should be aware of all safe practices and take all precautions described below and throughout this manual.

WARNING

Use specified SORVALL® rotors only. Use of another manufacturer's rotor can cause rotor failure which could result in personal injury and/or centrifuge damage.

When using radioactive, toxic, or pathogenic materials, be aware of all characteristics of the materials and the hazards associated with them in the event leakage occurs during centrifugation. In the event of a tube failure, a rotor without a biocontainment seal cannot protect you from particles dispersed into the air; if a rotor fails, the centrifuge cannot protect you from particles dispersed into the air. To protect yourself, we recommend additional precautions be taken to prevent exposure to these materials, for example, use of controlled ventilation or isolation areas.

Always be aware of the possibility of contamination when using radioactive, toxic, or pathogenic materials. Take all necessary precautions and use appropriate decontamination procedures if exposure occurs.

Never use any material capable of producing flammable or explosive vapors or creating extreme exothermic reactions.

Never exceed the maximum rated speed of the installed rotor; to do so can cause rotor failure.

Always reduce (derate) rotor speed as instructed in this manual whenever:

- the rotor speed/temperature combination exceeds the solubility of the gradient material and causes it to precipitate.
- the compartment load exceeds the maximum allowable compartment load specified.See Chapter 4, Operation.

Failure to reduce rotor speed under these conditions can cause rotor failure.

Centrifuges routinely deal with high energy levels and could move suddenly in the unlikely event of rotor failure. During centrifuge operation, never lean on or move the centrifuge, keep the surrounding area clear of objects (including all hazardous materials), and do not work on top of or next to the centrifuge.

Do not attempt to open the chamber door when the rotor is spinning; never override or otherwise disable any of the safety systems of the centrifuge.

CAUTION

Do not operate or precool a rotor at the critical speed, as this will have a detrimental effect on centrifuge component life. See Appendix, Rotor Information Table, for critical speeds of rotors.

Do not operate the centrifuge with the rotor out of balance. Operating the rotor out of balance can cause damage to the centrifuge drive assembly.

Do not operate the centrifuge unless the rotor is properly seated on the drive spindle and locked in place. See the rotor instruction manual.

Locate the centrifuge on a level surface to avoid rotor imbalance during operation.

The centrifuge can be damaged if it is connected to the wrong voltage. Check the voltage before plugging the centrifuge into a power source. Thermo is not responsible for incorrect installation. See Chapter 2.

Always maintain the centrifuge in the recommended manner. See Chapter 5, Care and Maintenance.

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Chapter 1: INTRODUCTION & DESCRIPTION

This manual provides you with the information you will need to operate and maintain your SORVALL® RC-5C PLUS Superspeed Centrifuge. If you encounter any problem concerning either operation or maintenance that is not covered in the manual, please contact our Marketing Technical Group for assistance. In the United States, call toll-free 800-522-7746; outside the United States, contact your local distributor or agent for SORVALL® products. SORVALL® product information is available on our internet web site at ***http://www.thermo.com*** or ***http://www.thermo.de***.

Centrifuge Description

The RC-5C PLUS is a high-speed (to 21 000 rpm) centrifuge used to separate substances of different densities at controlled temperatures. Some of the outstanding features of the RC-5C PLUS are:

- A high-performance brushless dc drive motor.
- Relative Centrifugal Force (RCF, or *g*-force) calculator. It allows you to calculate RCF before a run and display RCF at any time during a run.
- Automatic temperature compensation for all compatible SORVALL® superspeed rotors.
- Integrator ($\int\omega^2 dt$). It can be used either as a control or a display or both. When used as a control, the centrifuge will shut down based on a preselected integral value rather than a preselected time and when used as a display, the accumulated integral value will be displayed during and after a timed run.
- Automatic rate-controlled slow start and slow stop.
- Refrigeration system charged with CFC-free SUVA® refrigerant.
- Automatic diagnostic indicators to alert of a system malfunction, plus other indicators that let you know system status.
- Automatic self-test routine by the microcomputer. Every time the centrifuge is started, the microcomputer will go through a routine check to ensure its proper performance.

The centrifuge can be operated in several modes or a combination of modes. Run conditions are selected by setting the switches on the front control panel, and during operation, actual run conditions are indicated on easy-to-read displays. For your protection, system interlocks keep the centrifuge from starting if the chamber door is open, and prevent the door from being opened if a run is in progress and the rotor is spinning. System interlocks will also automatically terminate a run in progress if a system malfunctions.

The RC-5C PLUS drive system has a directly coupled, fan-cooled brushless dc motor designed to provide long life without the need to change motor brushes. The high-torque motor provides smooth, quiet operation at all speeds, while delivering precise speed control and exceptional acceleration and braking performance. The gyro-action self-centering drive design allows users to, in many cases, balance the centrifuge tubes by "eye" rather than by weighing them.

The refrigeration system, charged with environmentally-friendly CFC-free SUVA® refrigerant, offers reliable performance similar to earlier SORVALL® superspeed centrifuges. The high-capacity refrigeration system is a low temperature, hermetically-sealed unit that consists of a compressor, a condenser, an evaporator/rotor chamber, and interconnecting tubing. During operation, the refrigeration system will maintain selected temperatures within the range specified for the centrifuge.

The RC-5C PLUS accepts the SORVALL® superspeed rotors listed in the Rotor Information Table in the Appendix.

Refer to figure 1-1 to identify the parts of the RC-5C PLUS.

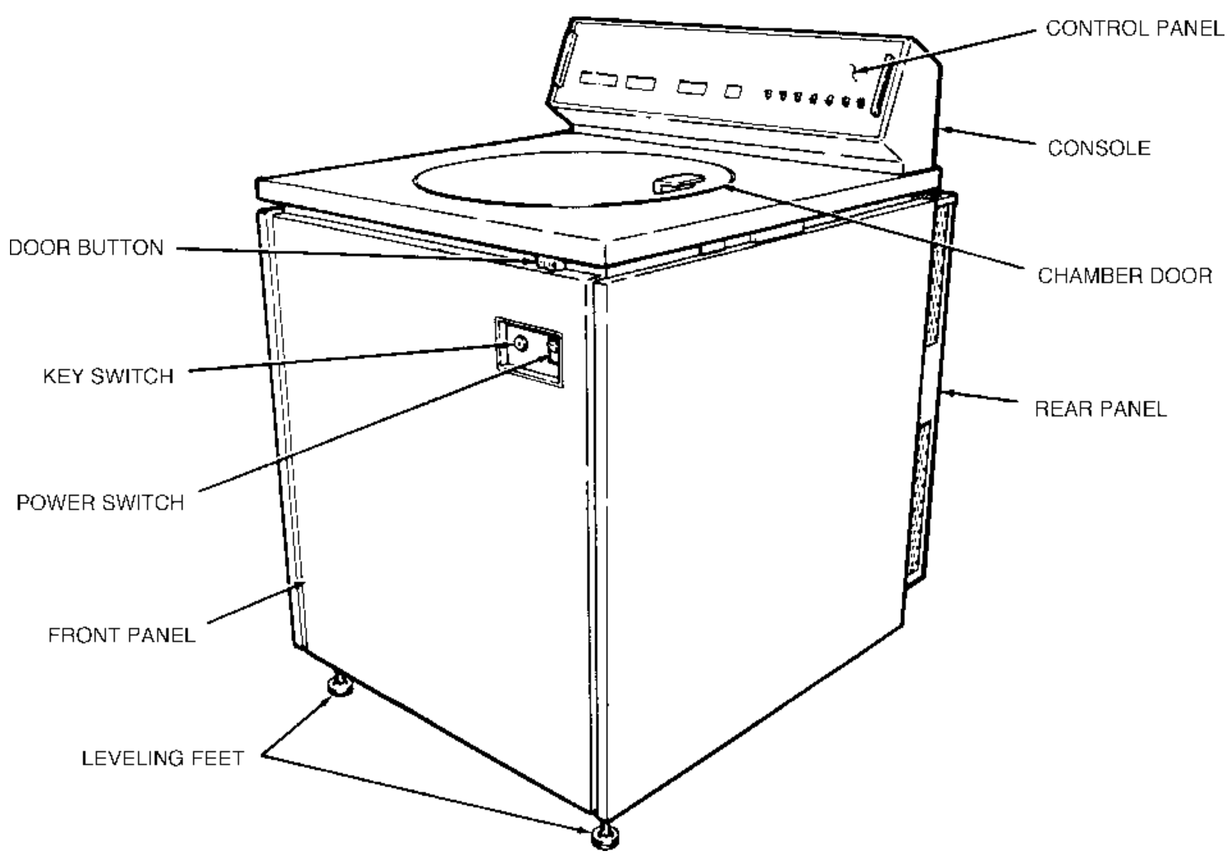


Figure 1-1 Centrifuge Parts Location and Identification

Centrifuge Specifications

Run Speed[1]	
Speed Selection Range (rpm)	50 to 21000
Speed Control Accuracy	±1% or 100 rpm, whichever is greater
Maximum Relative Centrifugal Force	51 427 *g*
Run Temperature	
Temperature Selection Range	–20 to +40°C
Temperature Control Range	+2 to +40°C[2,3]
Temperature Control Accuracy	±1°C[3,4]
Run Time Selection Range	0 to 99 hr, 59 min or Hold
Ambient Temperature Range	+15 to +38°C[3]
Mass (Weight)	362 kg (800 lb)
Dimensions	
Width	76 cm (30 in)
Height to top of control console	114 cm (45 in)
Depth	99 cm (39 in)
Noise Level	<62 dB[5]
Heat Output	4 kW[6] (13 500 Btu/h[6])
Electrical Requirements	
Input Power (single phase, 30 A)	240 V, 50 Hz 230 V, 60 Hz 230 V, 50 Hz 220 V, 50 Hz 208 V, 60 Hz 200 V, 60 Hz 200 V, 50 Hz
(polyphase, 30 A)	230 V, 50 Hz

1 Speed in revolutions per minute (rpm) is related to angular velocity, ω, according to the following:

$$\omega = (\text{rpm})\left(\frac{2\pi}{60}\right) = (\text{rpm})\,(0.10472)$$

Where ω = rad/s. All further references in this manual to speed will be designated as rpm.

2 May vary at very low speeds (below approximately 2000 rpm).

3 The centrifuge will operate at ambient temperatures up to 38°C, but refrigeration system performance may be less than optimal above 25°C.

4 After the centrifuge system has reached equilibrium.

5 For the SE-12 rotor at 21 000 rpm, measured 3 feet from the front panel at an approximated operator's height.

6 For the SS-34 rotor spinning 20 000 rpm at 4°C, after it has reached equilibrium. Other rotors, speeds, and temperatures cause the heat output to vary.

Centrifuge Specifications *(continued)*

Electrical Requirements, continued
Receptacles
- for 230 V, 50Hz, single phase . . . . 3-pin IEC 60309
- for all other single phase . . . . NEMA 6-30R
(for NEMA 6-30P grounded plug, supplied)
- for 230 V, 50Hz, polyphase . . . . 5-pin IEC 60309

Centrifuge Accessories

The following items are provided with the centrifuge:

Catalog No.	Description
74567	Condensed Operating Instructions
74559	Instruction Manual
68025	9/16-inch Wrench
91499	NORMAL/ZONAL Key

Chapter 2: INSTALLATION

After you receive your centrifuge, inspect it for damage before using it. The RC-5C PLUS centrifuge must be installed in a location that meets all of the electrical, location, and environment requirements that are specified below and on the next page. Installation instructions are on page 2-3.

Inspection

As soon as you receive your RC-5C PLUS, carefully inspect it for any shipping damage that may have occurred. If you find any damage, please report it immediately to the transportation company and file a damage claim, then notify Thermo. If any parts are missing, contact one of the Thermo district offices or the local representative of SORVALL® products. You will find a list of offices on the back cover of this manual.

Electrical Requirements

The appropriate power source must be available to plug the centrifuge into. Check the nameplate on the back panel of the centrifuge to determine the electrical configuration of your centrifuge, which should be one of the following:

200V, 60Hz, 30A, single phase	230V, 60Hz, 30A, single phase
200V, 50Hz, 30A, single phase	230V, 50Hz, 32A, single phase
208V, 60Hz, 30A, single phase	230V, 50Hz, 32A, polyphase
220V, 50Hz, 30A, single phase	240V, 50Hz, 30A, single phase

CAUTION

The centrifuge can be damaged if it is connected to the wrong line voltage, or if line voltage varies more than ±10% of its nominal value. Check the voltage before plugging the centrifuge into any power source. Thermo is not responsible for improper installation.

Check the supply line voltage with a voltmeter, then verify that the voltage indicated on the nameplate is in agreement with the measured line voltage. If the measured line voltage is not within 10% of the voltage specified on the nameplate, do not connect the power cord and operate the centrifuge. Damage to the centrifuge may result. To connect the centrifuge to a voltage other than what is specified on the nameplate (including polyphase), it will have to be rewired and its power cord may have to be replaced. Contact Thermo to have a Field Service Engineer do the rewiring.

Single phase RC-5C PLUS Centrifuges are equipped with a three-wire power cord with three-prong connector to fit a NEMA 6-30P receptacle or equivalent or, on 230V 50Hz centrifuges, an IEC 60309-type three-pin receptacle (32A, 2-pole and earth). 230V 50Hz *polyphase* RC-5C PLUS Centrifuges are equipped with a four-wire power cord with five-pin connector to fit an IEC 60309-type five-pin receptacle (32 A, 3-pole, neutral and earth).

A qualified technician may change the power cord to meet local electrical code requirements; the green and yellow wire is the ground and must be connected to the centrifuge frame.

A dedicated circuit is required. The ON/OFF main power switch is a 30-Amp circuit breaker; however, for emergency disconnect purposes, we recommend a separate means of power interruption in a remote location.

Environment Requirements

Ambient air temperature at the centrifuge air inlets must be between 15°C to 38°C (59°F to 100°F), with relative humidity ≤90%, for the centrifuge to operate. If the ambient air temperature is above 25°C, the centrifuge may not maintain low temperatures at high speeds, therefore, avoid areas near heat sources (for example, heating pipes and radiators). Also, avoid close grouping of centrifuges or other heat-producing laboratory equipment.

The centrifuge is intended for use in 1) a Pollution Degree 2 Environment, 2) an installation category II supply circuit, and 3) at a maximum altitude of 2000 meters.

Location Requirements

Locate the RC-5C PLUS centrifuge on a level floor. In addition to considering ambient temperature (see environment requirements, above), allowing adequate space for air circulation is important for the centrifuge to function properly. To ensure free air circulation, the centrifuge must be positioned so that no air vents are blocked, in a location that allows an additional 10 cm (4 inches) clearance from all sides of the centrifuge.

For safety, personnel should know that centrifuges routinely deal with high energy levels and could move suddenly in the unlikely event of a rotor failure. Laboratory management procedures should require that no person or any hazardous materials are within a “clearance envelope” boundary of 300 mm (12 inches) from the centrifuge while it is operating. During centrifuge operation, personnel should be instructed not to lean on or move the centrifuge, not to stay within the clearance envelope longer than necessary for operational reasons, and not to deposit potentially hazardous materials within the clearance envelope.

Installation

Install the RC-5C PLUS centrifuge as follows, observing all electrical, location, and environment requirements listed on the preceding pages:

1. *If you are installing a new centrifuge,* remove any packaging.

2. Roll centrifuge into position, then turn the two front feet (one at each corner) to lower them so that they both touch the floor.

3. If the chamber door is not already open, open it by following the emergency sample recovery procedure in Chapter5.

4. Install a rotor on the drive spindle WITHOUT its lid. Place a level on the center hub of the rotor.

CAUTION

The centrifuge can be seriously damaged if it is operated when it is not level.

5. Using the 9/16-inch wrench provided, alternately turn the two front feet to raise or lower the front corners of the centrifuge until the centrifuge is level and both feet bear weight. ***Read the CAUTION.***

6. Remove the level and the rotor from the rotor chamber.

7. Plug the centrifuge into the appropriate electrical outlet.

Chapter 3: CONTROLS, DISPLAYS & INDICATORS

This chapter describes the RC-5C PLUS centrifuge controls, displays, and indicators and includes their locations and functions.

Controls, Displays, & Indicators

The RC-5C PLUS control switches are used to select desired run parameters and, during a run, digital displays indicate actual run conditions, such as estimated sample temperature, rotor speed, remaining or elapsed run time or accumulated integral value. Indicators light up, as required, to show that you have selected certain run conditions (for example, HOLD or $\int \omega^2 dt$) or to let you know when the centrifuge is not functioning properly.

Refer to figure 3-1 for the location of the controls, displays, and indicators described in this chapter.

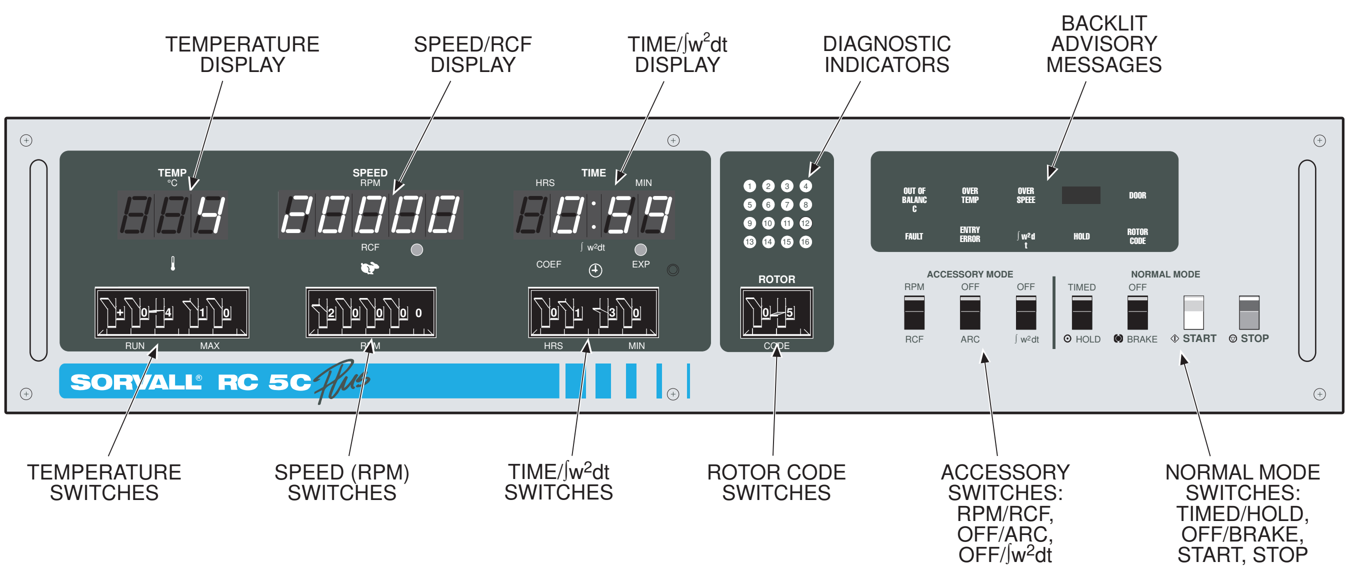
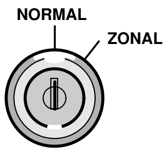
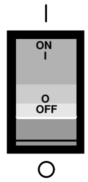


Figure 3-1. RC-5C PLUS Control Panel





Key Switch and Power Switch

The key switch and power switch are located in the upper right-hand corner of the front cabinet panel. The key switch is set using the key that is supplied with the centrifuge; the position of this switch determines the mode of centrifuge operation. The key should be kept in the NORMAL position unless you need to dynamically load the TZ-28 zonal rotor. The power switch (30 A circuit breaker) is an ON/OFF toggle switch that, when set to ON, applies power to the centrifuge.

Temperature Switches and Display

The temperature display indicates estimated sample temperature.

The RUN temperature switch is used to set desired sample temperature. The MAX temperature switch is used to set the overtemperature, which is the maximum permissible sample temperature. (If the sample temperature exceeds this limit, the centrifuge will shut off and the OVERTEMP message will light.)

Speed Switches, Display, & Indicator

The Speed/RCF display indicates rotor speed in rpm (revolutions per minute) or RCF (relative centrifugal force, commonly referred to as *g* force) when the RPM/RCF switch is pressed to RCF.

The indicator below the display lights when the RPM/RCF switch is pressed to RCF.

The RPM switches are used to set the desired run speed.

Time/$\int\omega^2 dt$ Switches, Display, & Indicator

The Time/$\int\omega^2 dt$ display shows one of the following values during a run: (1) accumulated run time if the TIMED/HOLD switch is set to HOLD, (2) remaining run time if the TIMED/HOLD switch is set to TIMED and the OFF/$\int\omega^2 dt$ switch is set to OFF, or (3) accumulated integral value if the OFF/$\int\omega^2 dt$ switch is set to $\int\omega^2 dt$. Time values are displayed in hours and minutes and integral values are displayed as a coefficient and an exponent (for example, 15 20 means $1.5\text{x}10^{20}$).

The indicator below the display will light if the OFF/$\int\omega^2 dt$ switch is set to $\int\omega^2 dt$.

The Time/$\int\omega^2 dt$ switches are used to select either the desired length of run time (hours and minutes) or the desired integral value (coefficient and exponent), depending on the setting of the OFF/$\int\omega^2 dt$ switch when the START switch is pressed. The centrifuge will shut off when the preselected value is achieved, provided the TIMED/HOLD switch is set to TIMED (if the switch is set to HOLD, the run will continue until STOP is pressed).

Rotor Code Switches

The code number of the rotor in use must be set on these switches for proper automatic temperature compensation, speed control, and RCF calculation. At the beginning of each run, the ROTOR CODE message light will flash on and off to remind you to enter the proper code number.

TIMED/HOLD Switch

The setting of this switch determines how the run will end:

- If the TIMED/HOLD switch is set at TIMED when the START switch is pressed, the run will end when the preselected length of time has elapsed or the preselected integral value has accumulated, depending on the setting of the OFF/$\int\omega^2 dt$ switch.

- If set at HOLD when the START switch is pressed, the run will continue until you press the STOP switch. If the setting is changed from TIMED to HOLD during a run, the run will not end until you press the STOP switch.

OFF/BRAKE Switch

When the OFF/BRAKE switch is set to BRAKE, the rotor will brake (rather than coast) all the way from set speed to 0 rpm at the end of the run, unless the OFF/ARC switch is set to ARC; if this is the case, the rotor will brake from set speed to 768 rpm, then continue to decelerate to 0 rpm at a controlled rate.

When the OFF/BRAKE switch is set to OFF the rotor will coast all the way from set speed to 0 rpm at the end of the run, unless the ARC is on; if this is the case it will coast to 768 rpm, then continue to decelerate at the controlled rate.

START Switch

The START switch starts the run when is it pressed.

STOP Switch

The STOP switch ends the run when it is pressed.

RPM/RCF Switch

This switch is normally set to RPM, which causes the SPEED display to show rotor speed. When pressed down to RCF during a run, the SPEED display numbers will change from the current rotor speed to the current relative centrifugal force (RCF, commonly referred to as *g* force) value. To be sure that the RCF value is correct, make sure the proper rotor code number is set on the ROTOR CODE switches. When the RPM/RCF switch is released, the display will change back to show rotor speed.

This switch can also be used to calculate RCF values before a run has been started (see Chapter 4).

OFF/ARC Switch

When the OFF/ARC switch is set to ARC it causes an automatic rate-controlled slow start from 0 rpm to 512 rpm and a slow stop from 768 rpm to 0 rpm. The setting of the OFF/BRAKE switch will determine the rate of deceleration from set speed down to 768 rpm—if it is set to OFF, the rotor will coast from set speed to 768 rpm; if it is set to BRAKE, the rotor will brake from set speed to 768 rpm.

If the OFF/ARC switch is set to OFF, the rotor will accelerate to set speed at the normal (maximum) rate, then it will decelerate from set speed down to 0 rpm in accordance with the setting of the OFF/BRAKE switch.

OFF/$\int\omega^2dt$ Switch

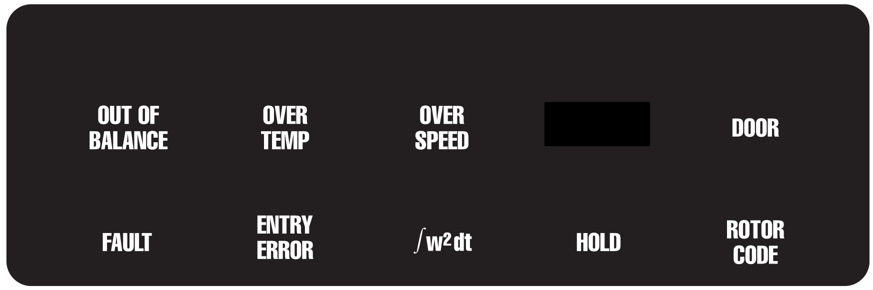
- If the OFF/$\int\omega^2dt$ switch is set to $\int\omega^2dt$ and the TIMED/HOLD switch is set at TIMED when the START switch is pressed, the TIME display will show accumulated integral value during the run and the run will end when the preselected integral value has accumulated.

- If the OFF/$\int\omega^2dt$ switch is set to $\int\omega^2dt$ and the TIMED/HOLD switch is set at HOLD when the START switch is pressed, the TIME display will show accumulated run time and the run will continue until you press the STOP switch. However, the setting on the switches has been interpreted as an integral value rather than time; therefore, if you change the setting of the TIMED/HOLD switch to TIMED during the run, the display will change to show accumulated integral value and the run will end when the set value is reached.

- If the OFF/$\int\omega^2dt$ switch is set to OFF when the START switch is pressed, the centrifuge will operate in either a timed mode or a continuous run (HOLD) mode, depending on the setting of the TIMED/HOLD switch. The TIME display will show either remaining run time (TIMED) or accumulated run time (HOLD). During a TIMED run, the accumulated integral value can be displayed by changing the setting of this switch to $\int\omega^2dt$ (the run will still be controlled by time, not integral). Even though the run is controlled by time, the integral value accumulates from the time the START switch is pressed until the rotor decelerates to 0 rpm at the end of the run.

- At the end of any TIMED run (but before the START switch is pressed again), the integral recall value for the run can be displayed by changing the OFF/$\int\omega^2dt$ switch to $\int\omega^2dt$. If you know the integral recall value of a particular run, you can then duplicate the run by selecting the integrator mode and setting the switches for the integral value (see Integrator Mode in Chapter 4).

Backlit Advisory Messages



The RC-5C PLUS has nine operator advisory messages on the control panel. These messages are backlit; each message lights only when the condition that it represents exists. The meaning of each message is given below, along with the corrective action.

OUT OF BALANCE

Indicates excessive rotor imbalance. Run in progress terminated. Remove the rotor and balance it according to the directions in the rotor instruction manual, then restart the run.

OVERTEMP

Indicates run terminated because the chamber temperature exceeded the desired maximum run temperature selected on the MAX temperature switch. Some problems that could cause this are:

- run temperature setting may be too low for the rotor/speed combination; check rotor instruction manual to verify temperature setting,
- room ambient temperature is above 25°C, or
- inadequate air circulation (see Location Requirements, page2-1).

Check each of these possible causes before notifying your Thermo Field Service Engineer of the problem.

OVERSPEED

Indicates the detected speed is greater than 22 000 rpm and run in progress terminated. If the ENTRY ERROR message is also lit, see page 4-11 for possible cause. Otherwise, notify your Thermo Field Service Engineer of the overspeed condition.

DOOR

Indicates one of the following:

- Pressed START with the centrifuge chamber door open and the key switch set to NORMAL. The centrifuge will not start. Close the chamber door and start the centrifuge.
- Rotor speed is above 1500 rpm with the chamber door open and the key switch set to ZONAL. Run in progress terminated. Notify Thermo Field Service Engineer.
- Rotor is spinning with the chamber door open and the key switch set to NORMAL. Run in progress terminated. Notify Thermo Field Service Engineer.

FAULT

Blinks on and off whenever a diagnostic indicator lights up; the indicator represents a condition that has caused the run to end (diagnostic indicators number 1-8) See Diagnostic Indicators later in the chapter.

ENTRY ERROR

Lights when a wrong entry has been made on one of the control settings. See page 4-11 for a list of possible entry errors.

$\int\omega^2 dt$

Indicates that you have selected the integral ($\int w^2 dt$) mode; the setting on the TIME switches is interpreted as an integral value rather than a time.

HOLD

Indicates that the TIMED/HOLD switch is set at HOLD and the run will continue until you press the STOP switch.

ROTOR CODE

Blinks on and off for a few seconds at the beginning of each run as a reminder to enter the proper rotor code number (see Table 4-1).

Diagnostic Indicators

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

These indicators, numbered 1 through 16, help troubleshoot a problem when the centrifuge is not operating properly. When any of the indicators light, it means a problem exists that is affecting the operation of the centrifuge. Each indicator represents a different problem; some problems will cause the centrifuge to shut off, others will not, depending on the seriousness of the problem. Of the sixteen indicators, only eleven (1-12) are currently being used; the other five are there for future use, if needed. The meaning of each light is given below, along with the corrective action.

1 CONTROL SYSTEM FAILURE
Turn the main power off and back on, then restart the run. If the light comes on again, notify your Thermo Field Service Engineer.

2 PROGRAM FAILURE
Notify Thermo Field Service Engineer.

3 MEMORY SYSTEM FAILURE
Notify Thermo Field Service Engineer.

4 DRIVE SYSTEM FAILURE
Notify Thermo Field Service Engineer.

6 NO ROTOR
The microcomputer has detected a sudden and sustained increase in rpm, because there was no rotor installed when the START switch was pressed. The centrifuge ran for a few seconds then shut off. Install a rotor and restart the run.

7 REFRIGERATION SYSTEM FAILURE
There was no apparent drop in chamber temperature thirty seconds after the refrigeration system started to cool. Notify your Thermo Field Service Engineer.

8 TEMPERATURE SENSOR FAILURE
Chamber air temperature sensor has failed. Notify your Thermo Field Service Engineer.

9 TEMPERATURE SENSOR FAILURE
Chamber wall temperature sensor has failed. Notify your Thermo Field Service Engineer.

10 COMPUTER SYSTEM FAILURE
The computer has received erroneous information. The condition will clear and the light will go out if the problem is momentary. If the condition persists, notify your Thermo Field Service Engineer.

11 TACHOMETER ERROR
The computer has detected changes in rpm that are beyond the normal range, indicating that the tachometer input frequency is unstable. The condition will clear and the light will go out if the problem is momentary. If the condition persists, notify your Thermo Field Service Engineer.

12 REGISTER OVERFLOW
This problem could be momentary; if it is, the condition will clear and the light will go out. Also, a wrong entry on one of the control switches may cause this light to come on—if the ENTRY ERROR message is lit, check all control settings. If the condition persists, notify your Thermo Field Service Engineer.

5 NOT USED

13 NOT USED

14 NOT USED

15 NOT USED

16 NOT USED

Chapter 4: OPERATION

This chapter provides step-by-step instructions on how to set the centrifuge power ON, open the chamber door, and perform a run in the normal mode. It also describes the rate control, zonal, and integrator modes of operation and how to precool the rotor. *Read and observe the Important Safety Information supplied on page iii at the front of this manual.*

The chapter contains supplementary information on how to calculate relative centrifugal force (RCF); how to do a test run for low speed and low temperature operation; and what will cause an ENTRY ERROR. The controls and displays referred to in this chapter are described in detail in Chapter 3.

Setting the Centrifuge Power ON

The centrifuge power ON / OFF switch is located in the upper-right corner of the front cabinet panel, below the control panel (see figure 1-1). Press the top of the switch to set the centrifuge power ON.

Opening the Chamber Door

Press the door release button (located under the right-front corner of the top deck, see figure1-1) to r elease the door latch and open the chamber door.

Normal Mode Operation

WARNING When loading the rotor, be sure not to exceed the maximum compartment mass of the rotor (see the Rotor Information Table in the Appendix). If maximum compartment mass is exceeded, the maximum operating speed must be lowered (see Reducing Speed for Rotor Compartment loads in Excess of Design Mass later in this chapter). Failure to do so can cause rotor failure, which could result in centrifuge damage and personal injury.

CAUTION Failure to load and install the rotor in accordance with the rotor instruction manual could result in damage to the centrifuge. The rotor cover must be on and locked in place and the rotor must be locked to the drive spindle.

The normal mode of operation should be used for most RC-5C PLUS centrifuge runs. (EXCEPTIONS: To slowly accelerate or decelerate fragile gradients or samples, see Rate Control [ARC] Operation. To dynamically load a zonal rotor, see Zonal Mode Operation. To control a run with the integrator, see Integrator Mode Operation.)

To perform a normal centrifuge run, the centrifuge power must be set ON and a rotor must be loaded and installed according to the instructions in the rotor manual ***(read the WARNING and the CAUTION)***. If the sample temperature during the centrifuge run is critical, we recommend that you precool the rotor and chamber as described on page 4-7 before beginning this procedure.

NOTE The controls and displays referred to in this procedure are defined in Chapter 3.

If the ENTRY ERROR message lights at any time during this procedure, refer to page 4-11 for possible causes.

1. Set the main power switch to ON.

2. Set the RUN and MAX temperature switches to the desired run temperature and maximum temperature. The MAX temperature setting should be for a value that is at least 5°C higher than the RUN temperature setting.

NOTE For optimal temperature control at RUN temperatures below ambient, both the rotor and the rotor chamber should be at the desired RUN temperature before the run is started. If the rotor was precooled in the centrifuge, the chamber will already be at the desired temperature. If the rotor was precooled by some other means, you should wait until the temperature display indicates the desired RUN temperature before starting the run. The run will not start as long as the displayed temperature is greater than the MAX temperature setting.

3. Set the key switch on the front panel to NORMAL.

4. Open the chamber door.

5. If applicable, make sure the rotor cover is installed on the rotor and, for fixed-angle rotors, secured.

6. Place the rotor on the drive spindle and lock it in place by turning the rotor locking knob counterclockwise.

7. Set the ROTOR CODE switches for the proper ROTOR CODE number (see Table 4-1).

8. Close the chamber door.

9. Set the RPM switches for the desired run speed.

Table 4-1. Rotor Codes

Rotor Code	Rotor	Rotor Code	Rotor	Rotor Code	Rotor
Fixed-Angle		06	SE-12	17	S-20/20
05	SS-34	12	SH-MT	16	S-20/36
27	SLA-1000	09	SM-24	29	SH-3000 -buckets
26	SA-300	14	F-28/13	31	SH-3000 -microplates
36	SA-512	15	F-28/36	*Vertical/Zonal*	
04	SA-600	24	F-28/50	01	SV-288
37	SA-800	25	F-20/MICRO	02	SV-80
32	SLA-600TC	*Swinging-Bucket*		11	TZ-28
28	SLA-1500	23	HB-6	21	TZ-28/DL -dynamic load
30	SLA-3000	07	HB-4	*Continuous Flow*	
34	SLC-1500	08	HS-4	19	SS-34/KSB-R
35	SLC-3000	13	SH-80	20	TZ-28/GK
33	SLC-4000	18	S-20/17		

10. Make sure the OFF/$\int \omega^2 dt$ switch is set to OFF.

11. Set the TIMED/HOLD switch:

    - For a timed run, set the switch to TIMED, then set the HRS and MIN switches for the desired length of run time.

    - For a continuous run, set the switch to HOLD (the setting on the HRS and MIN switches is ignored). When HOLD is selected, the HOLD message indicator light will come on.

12. Set the OFF/BRAKE switch to the desired setting (refer to Chapter 3). Set the OFF/ARC switch to OFF.

WARNING
Do not leave rotors or other objects on centrifuge surfaces during operation.

13. Press the START switch. (The ROTOR CODE advisory message will blink for a few seconds as a reminder to set the proper ROTOR CODE number.)

NOTE To end a run in HOLD or before the selected run time has elapsed, press the STOP switch.

If you want to see the accumulated integral value anytime during a TIMED run, change the setting of the OFF/$\int \omega^2 dt$ switch to $\int \omega^2 dt$. As long as you change the setting of this switch AFTER the START switch is pressed it will not have any affect on how the run will end - the run will still end when the preselected time has elapsed.

CAUTION
To reduce the possibility of samples freezing, remove the rotor from the centrifuge chamber as soon as possible after it stops spinning.

14. After the rotor has come to a stop and the door has unlatched, open the chamber door and remove the rotor. ***Read the CAUTION.***

NOTE We recommend keeping the chamber door closed after the rotor has been removed to inhibit the formation of condensation on the chamber walls.

The run can be repeated with the same parameters by installing the rotor, closing the chamber door, and pressing START. The selected speed, time, and temperature are retained from previous run.

Rate Control (ARC) Operation

The automatic rate control (ARC) accessory provides a slow, controlled acceleration from 0 to 512 rpm and a slow, controlled deceleration from 768 to 0 rpm. The ARC should be used when centrifuging gradients or fragile pellets. To do a rate-controlled run, follow the Normal Mode Operation procedure, except set the OFF/ARC switch to ARC in Step 12 to activate the rate control.

WARNING
When loading the rotor, be sure not to exceed the maximum compartment mass of the rotor (see the Rotor Information Table in the Appendix). If maximum compartment mass is exceeded, the maximum operating speed must be lowered (see Reducing Speed for Rotor Compartment loads in Excess of Design Mass later in this chapter). Failure to do so can cause rotor failure, which could result in centrifuge damage and personal injury.

CAUTION
Failure to load and install the rotor in accordance with the rotor instruction manual could result in damage to the centrifuge. The rotor cover must be on and locked in place and the rotor must be locked to the drive spindle.

CAUTION
Do not operate the rotor at its critical speed (see the Rotor Information Table in the Appendix).

Zonal Mode Operation

The zonal mode of operation must be used when dynamically loading the gradient and sample into a SORVALL® TZ-28 Zonal Rotor. When the zonal mode is activated, the centrifuge will accelerate to a low speed for rotor loading and when loading is complete, accelerate to the set run speed.

Preparation for Loading

Assemble the TZ-28 rotor according to the instructions in the rotor instruction manual, then:

NOTE If desired, precool the rotor in the centrifuge according to the procedure on page 4-7.

Read the WARNING and the CAUTION.

1. Set the main power switch to ON.
2. Set the key switch on the front panel to ZONAL.
3. Press the door release button, and open the chamber door.
4. Install the rotor as instructed in the rotor manual. Set the ROTOR CODE switch to 11.
5. Set the RPM switch to the desired loading speed, which must be between 50 and 1400 rpm (1400 rpm is the recommended speed). ***Read the CAUTION.***
6. Set the OFF/$\int \omega^2 dt$ switch to OFF.
7. Set the RUN and MAX temperature switches to the desired run temperature and maximum temperature. The MAX temperature setting should be for a value that is at least 5°C higher than the RUN temperature setting.

NOTE For optimal temperature control at RUN temperatures below ambient, both the rotor and the rotor chamber should be at the desired RUN temperature before the run is started. If the rotor was precooled in the centrifuge, the chamber will already be at the desired temperature. If the rotor was precooled by some other means, you should wait until the temperature display indicates the desired RUN temperature before starting the run. The run will not start as long as the displayed temperature is greater than the MAX temperature setting.

9. Set the TIMED/HOLD switch:

   - For a timed run, set the switch to TIMED, then set the HRS and MIN switches for the desired length of run time. The timer will start as soon as you press the START switch; therefore, include the time it will take to load the rotor in the run time you select.

   - For a continuous run, set the switch to HOLD (the setting on the HRS and MIN switches is ignored). When HOLD is selected, the HOLD message indicator light will come on.

10. Set the OFF/BRAKE switch to the desired setting (refer to Chapter 3). If the rotor already has the gradient in it, set the OFF/ARC switch to ARC to activate the rate control; it the rotor is empty, set the switch to OFF.

Loading

WARNING

When operating the centrifuge with the chamber door open and the rotor spinning, remove any articles that could fall into the rotor chamber (for example, jewelry, necktie, objects in shirt pockets). Tie back long hair and roll up shirt sleeves. Do not leave rotors or other objects on centrifuge surfaces during operation.

1. Press the START switch. (The ROTOR CODE advisory message will blink for a few seconds as a reminder to set the proper ROTOR CODE number.)

NOTE The timer will start as soon as you press the START switch; therefore, include the time it will take to load the rotor in the run time you select.

2. Wait for the rotor to reach the selected loading speed, then load the rotor according to the instructions in the rotor instruction manual. When the rotor is loaded, disconnect any equipment that was used to load it.

3. Close the chamber door.

4. Set the RPM switches for the desired run speed.

5. Set the OFF/ARC switch to ARC so there will be a rate-controlled slow stop at the end of the run (see Rate Control [ARC] Operation).

Acceleration and Deceleration

CAUTION

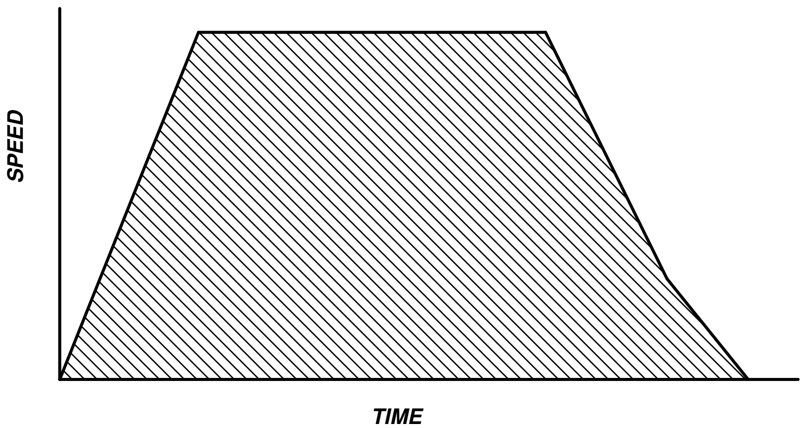
To reduce the possibility of samples freezing, remove the rotor from the centrifuge chamber as soon as possible after it stops spinning.

After you have closed the chamber door and set the run speed, the rotor will accelerate to the set speed, run for the selected length of time, then decelerate to a stop. If the run was in the HOLD mode, press the STOP switch to end the run; as soon as you press the STOP switch the rotor will begin to decelerate.

NOTE The accumulated integral value can be displayed during a run the same as for a NORMAL run.

Integrator Mode Operation

The integrator mode can be used in place of the timer to control the length of the centrifuge run. The integral value ($\int\omega^2 dt$) represents the actual centrifuge force generated by the rotor accumulated over time.



$$\int\omega^2 dt = [(\mathrm{rpm}/60)(2\pi)]^2\,(t_2\text{-}t_1)$$

$(t_2\text{-}t_1)$ = time in seconds

Figure 4-1. Integral Value

$\int\omega^2 dt$ is the integral value. The integral value is the area under the curve (as represented by the grey area in the drawing above). The larger the integral value, the more total centrifugal force (time and *g*for ce) applied to the sample. The use of the integrator will compensate for changes in rotor load and other factors that may change the rate acceleration in the RC-5C PLUS. For a more detailed explanation of the advantages of using the integrator, contact the SORVALL® Applications Laboratory.

The RC-5C PLUS allows you to obtain the integral value generated during a normally timed run by pressing the OFF/$\int\omega^2 dt$ switch to $\int\omega^2 dt$ when the run has stopped (see Integral Recall). The integral value can then be used to control subsequent centrifuge runs.

This procedure specifies how to set up a run to be controlled by an integral value. Prepare the rotor according to the instructions in the rotor instruction manual, then follow the instructions below.

NOTE If desired, precool the rotor in the centrifuge according to the procedure on page 4-7.

1. Follow Steps 1 through 9 and Step 12 in Normal Mode Operation to install a rotor, set run temperature and speed, and set brake. To use the rate control, see Rate Control (ARC) Operation. ***Follow all WARNINGS and CAUTIONS.***

2. Set the OFF / $\int \omega^2 dt$ switch to $\int \omega^2 dt$.

3. Set the TIMED / HOLD switch to TIMED, then set the COEF and EXP switches for the desired integral value (for example, 15 20 means $1.5\text{x}10^{20}$).

NOTE The TIMED/HOLD switch should never be set at HOLD during an $\int \omega^2 dt$ run; if it is, the display will show accumulated run time, and the run will not end until you press the STOP switch.

4. Press the START switch. The $\int \omega^2 dt$ advisory message on the control panel will light. (The ROTOR CODE advisory message will blink for a few seconds as a reminder to set the proper ROTOR CODE number.)

NOTE The setting of the OFF/$\int \omega^2 dt$ switch can be changed to OFF any time during a run to have the display (TIME) show the length of time that has elapsed since the run was started (the numbers in the display will change to represent hours and minutes instead of the integral value). The run will still terminate when the preselected integral value has accumulated.

To end a run before the selected integral value has accumulated, press the STOP switch.

CAUTION

To reduce the possibility of samples freezing, remove the rotor from the centrifuge chamber as soon as possible after it stops spinning.

Integral Recall

At the end of any TIMED run (normal or zonal mode) you can recall the integral value ($\int \omega^2 dt$) at timeout and use this value in the integrator ($\int \omega^2 dt$) mode to duplicate the run. When the rotor has stopped, change the setting of the OFF / $\int \omega^2 dt$ to $\int \omega^2 dt$; the integral value at timeout will appear in the TIME display. The value must be recalled before another run is started or before the main power is set OFF.

Rotor Precool

If you plan to run a temperature-sensitive sample in the RC-5CPLUS centrifuge, we recommend that you precool the rotor and the centrifuge before loading the sample. This will ensure that the rotor and chamber temperatures are at equilibrium at the start of the run.

CAUTION

Failure to load and install the rotor in accordance with the rotor instruction manual could damage the centrifuge. The rotor cover must be on and locked in place and the rotor must be locked to the drive spindle.

1. Set the centrifuge power ON and open the chamber door.

2. Install the empty rotor (with cover installed, if applicable). Lock it to the drive spindle by turning the rotor locking screw counterclockwise. Close the chamber door.

3. Set a run speed of 2000 rpm.

4. Set the TIMED/HOLD switch to HOLD.

5. Set the RUN temperature switch for desired run temperature.

6. Set the MAX temperature switch for a value higher than the temperature displayed to avoid an overtemperature condition.

7. Set all other controls as you would for a normal mode run.

8. Press the START switch. The rotor will accelerate to 2000 rpm and quickly cool to the selected run temperature. It will typically take the rotor 30 minutes to cool, but the actual time will vary depending on the rotor weight and rotor material. When the displayed temperature equals the run temperature setting, stop the run.

9. After the rotor has come to a stop, open the chamber door and remove the rotor lid. Place the samples in the rotor and balance the load as specified in the rotor instruction manual.

10. Re-secure the rotor lid. Lock the rotor to the drive spindle. Close the chamber door.

11. Perform the desired centrifuge run.

Reducing Speed for Loads in Excess of Design Mass

There is a maximum allowable compartment mass established for each rotor (see the Rotor Information Table in the Appendix or the individual rotor manual). To prevent rotor failure, the total contents of any compartment, including specimen, tubes, sealing assembly, and adapters (if used), must not exceed the specified maximum compartment mass unless rotor speed is reduced proportionately.

WARNING

Failure to reduce rotor speed when compartment load exceeds maximum allowable compartment load can lead to rotor failure.

Strict adherence to the maximum allowable compartment mass or reduced rotor speed is required to prevent rotor failure. ***Read the WARNING.*** If the maximum compartment mass is greater than the value specified for the rotor, use the following formula to determine the reduced rotor speed that is required:

$$\text{Reduced Speed} = \text{Maximum Rotor Speed} \times \sqrt{\frac{\text{Maximum Compartment Mass}}{\text{Actual Compartment Mass}}}$$

RCF Calculation

The RCF accessory is used to calculate relative centrifuge force (RCF, also known as *g*-force) values.

The accessory allows you to quickly determine the speed at which you must run a particular rotor to achieve a desired RCF value. To calculate the speed at a particular RCF:

1. Turn the main power ON but do not start the centrifuge; the rotor must be at 0 rpm to calculate the speed that corresponds to a particular RCF.

2. Set the ROTOR CODE switches for the code number of the rotor you will use. (Rotor codes are given in Table 4-1.)

NOTE The RCF values calculated for the SM-24 Rotor (code number 09) are the values for the outer row of the rotor.

3. Hold the RPM/RCF switch down to RCF.

4. The SPEED display will show the RCF value (for the identified rotor) at the speed that is set on the RPM switches.

5. Adjust the speed setting (on the RPM switches) until the desired RCF value appears in the SPEED display; the speed set on the RPM switches is the speed at which you have to run that rotor to achieve the displayed RCF.

NOTE If the ENTRY ERROR advisory message lights, you have the speed switches set for a value higher than the maximum speed of the identified rotor. Make sure the correct rotor or rotor code is selected.

The RCF accessory can also be used to view the RCF at a particular speed. Press the RPM/RCF switch down to view the RCF value (it will appear in the SPEED display). The RCF will correspond to the speed set on the RPM switches when rotor is at rest or to the actual speed (shown in the SPEED display) when a run is in progress.

Test Run for Low Speed and Low Temperature Operation

If the centrifuge is operated at a speed less than 2000 rpm and a temperature 2°C or less, the refrigeration system may have difficulty maintaining the indicated sample temperature within 1°C of the set temperature. This condition may cause the sample to freeze; therefore, when the speed and temperature are set below the values given above, we recommend that you do a test run to determine a temperature setting that will achieve the results you want and prevent the sample from freezing. This test run procedure should be used for every run where the rotor speed and sample temperature are this low because each speed/temperature/rotor combination may give different results.

1. Prepare two tubes or bottles of dispensable fluid and place them in the rotor. Balance the rotor according to the instructions in the rotor instruction manual.

NOTE The dispensable fluid should have a freezing temperature well below the desired sample temperature.

2. Set the RUN temperature switch to the desired sample temperature.

3. Install the rotor in the centrifuge and run it for at least two hours at the speed for which the temperature setting is being determined.

4. Stop the centrifuge. Wait for the rotor to stop then immediately open the chamber door and measure the actual sample temperature using an immersible centigrade thermometer.

5. Adjust the RUN temperature switches upward or downward according to the temperature differential between the measured temperature and the set run temperature.

   For example: If the measured sample temperature is -2°C and the set run temperature is +2°C, there is a 4°C differential. To obtain the +2°C sample temperature you should reset the set RUN temperature switches to +6°C. (Setting the higher temperature would prevent the sample from freezing.)

Entry Errors

Any of the following conditions will cause the ENTRY ERROR advisory message to light:

- The MAX temperature switch is set at or below the value set on the RUN temperature switch. In this case, the MAX temperature that the system will use is the RUN temperature plus seven degrees. Change the MAX temperature setting for a value at least 5°C higher than the RUN temperature setting.

- The RPM switches are set for a speed below 50 rpm. The system will default to a 50 rpm setting. Change the speed setting.

- The RPM switches are set at or above 105% of the maximum speed of the identified rotor. Check the ROTOR CODE setting to make sure you have selected the proper code number and check the speed setting to make sure it is within range for the rotor.

- The TIMED/HOLD switch is set at TIMED, the OFF/$\int \omega^2 dt$ switch is set at OFF, and the TIME (HRS and MIN) switches are set at zero. The run will not start.

- The TIMED/HOLD switch is set at TIMED, the OFF/$\int \omega^2 dt$ switch is set at $\int \omega^2 dt$, and the COEF switch is set at zero. The run will not start.

- The ROTOR CODE switches are set at a number that is not used (see Table 4-1 for numbers that are used); the control values will default to those for a ROTOR CODE setting of “00”.

Chapter 5: CARE and MAINTENANCE

This chapter describes routine maintenance procedures for your RC-5C PLUS Centrifuge. It also includes cleaning and decontamination recommendations and the Service Decontamination Policy. As the user, it is your responsibility to make certain these procedures and recommendations are followed. In addition to these routine procedures, to keep your centrifuge in good working condition and ensure accurate test results, we recommend that you have the centrifuge serviced and have the speed control, timer, temperature control, and rotor imbalance checked annually by a Thermo Field Service Engineer or other qualified service personnel. If further service is needed, contact your Thermo Field Service Engineer.

Maintenance

WARNING

There are no user-serviceable items inside the centrifuge. Because of the high voltages in the centrifuge, anyone who is not properly trained in electronics must not test or repair the electrical circuits.

To gain the most in safety, performance, and useful life from your centrifuge, it is necessary to properly maintain it. Proper maintenance is a simple and inexpensive way to help prevent major failures. In addition to the maintenance described below, a Thermo service contract, which includes a yearly Preventive Maintenance visit, is recommended to keep your centrifuge in good condition.

Table 5-1 suggests a maintenance schedule.

Table 5-1. Maintenance Schedule

Maintenance	Frequency
Clean the rotor chamber	Daily or immediately after a spill
Wash the tapered spindle	Once a week
Clean the cabinet panels	Once a month
Have condenser fins cleaned	Once a year or whenever centrifuge is serviced; more often if dust accumulates significantly
Check LEDs and indicators	Once a year or whenever the displayed numbers seem erroneous
Have ground continuity tested	Once a year or whenever centrifuge is serviced
Clean the air inlet on the drive box (wipe with cloth)	Once a month

WARNING
If hazardous materials have been processed in the centrifuge, observe all necessary precautions when you are cleaning or servicing the centrifuge to avoid the possibility of contamination.

Cleaning and Decontamination

Rotor Chamber

The rotor chamber should be defrosted and cleaned periodically to maintain efficient cooling. To defrost the chamber, install a rotor, close the chamber door, set the RUN temperature switch for 25°C and set the MAX temperature switch for 30°C, then run the centrifuge until the frost melts. When defrosting is complete, wipe the chamber dry with a damp sponge or cloth.

CAUTION
Chlorides (for example, bleach solutions) are extremely harmful to aluminum alloy rotors and can cause stress corrosion cracking. Therefore, do not use chlorides to decontaminate the chamber.

Use 70% ethanol to disinfect the rotor chamber and the rubber door seal or a 2% glutaraldehyde solution to sterilize them, then follow with several deionized water rinses. For general radioactive decontamination, use a solution of equal parts 70% ethanol, 10% SDS, and water. Follow this with ethanol rinses, then deionized water rinses. Dry with a soft absorbent cloth. Dispose of all wash solutions in proper radioactive waste containers.

To prevent condensation from forming in the rotor chamber, keep the chamber door closed when the chamber is cold.

Tapered Drive Spindle

Wipe the drive spindle with a soft cloth each time a rotor is to be installed to reduce the chance of the rotor sticking. Once a week, wash the drive spindle with warm water.

Cabinet

Clean the cabinet panels, top deck, and chamber door with a mild, *nonalkaline* detergent and water. Do not use abrasive cleansers.

WARNING
Only a qualified technician should attempt to clean the condenser fins. Before accessing the condenser, technicians should unplug the power cord to avoid exposure to hazardous electrical circuits. Also, the condenser fins are very sharp; to avoid personal injury, technicians should use care when cleaning fins.

Refrigeration System Condenser Fins

To maintain the efficiency of the refrigeration system, the condenser fins (located in the rear of the centrifuge) must be kept free of dust and dirt. Condenser fins should be cleaned with a brush or a vacuum cleaner at least annually, more often if dust accumulates significantly. The fins will bend easily; be very careful when cleaning them. Due to hazards involved, only a qualified technician should attempt to clean the condenser fins.

Lubrication

All components are prelubricated and require no further lubrication. The refrigeration unit is hermetically sealed and the ball bearings in the centrifuge motor are permanently lubricated.

LED & Indicator Test

Once a year or whenever displayed numbers seem erroneous, you should test the LEDs and indicators on the control panel to make sure they all work. If even one segment of an LED segment does not work, you could get an incorrect reading in the display.

To test the LEDs and indicators:

1. Set the main power OFF.

2. Set the ROTOR CODE switches to "00" (the setting of all other switches is irrelevant).

3. Set the main power ON. When you do, watch the control panel and make sure the displays and indicators light as follows:

   - the number 8 should light in each digit space across all of the displays,
   - the minus sign should light in the TEMP display,
   - all nine backlit advisory messages should light,
   - diagnostic indicators 1 through 12 should light,
   - the $\int\omega^2 dt$ indicator should light.

NOTE The RCF indicator will not light; to test this indicator, just press the RCF switch.

If any of the LEDs or indicators are not working, contact a Thermo Field Service Engineer to repair it.

Parts Ordering Information

To order replacement parts, in the United States, call Thermo toll-free 1-800-522-7746; outside the United States, contact the nearest Thermo office (see back cover) or your local representative for SORVALL® products. Be sure to provide a description of the part, centrifuge model, and centrifuge serial number.

For a complete list and description of available SORVALL® centrifuges, accessories, rotors, tubes, bottles, and adapters, please refer to the most current SORVALL® Product Guide. SORVALL® product information is available on our internet web site at ***http://www.thermo.com*** or ***http://www.thermo.de***.

Emergency Sample Recovery

> **WARNING**
> When the main power shuts off, the brake will not operate. Wait until the rotor stops (approximately 15 minutes) before using the mechanical override. Reaching into the rotor chamber before the rotor has stopped spinning could cause personal injury.

If the main power shuts off because of a power failure or a system malfunction while the rotor is spinning, the RC-5C PLUS chamber door will not unlatch. A mechanical override is provided to allow sample recovery in the case of an emergency. This procedure should never be used routinely and is intended for emergency sample recovery only.

The door latch override button is recessed beneath the top deck to the left of the door button (see figure4-1). To open the chamber door, push the door latch override button with a pencil or similar object and—at the same time—push the door button. The chamber door will open.

NOTE The chamber door will not open if the door latch override button and door button are not pushed at the same time.

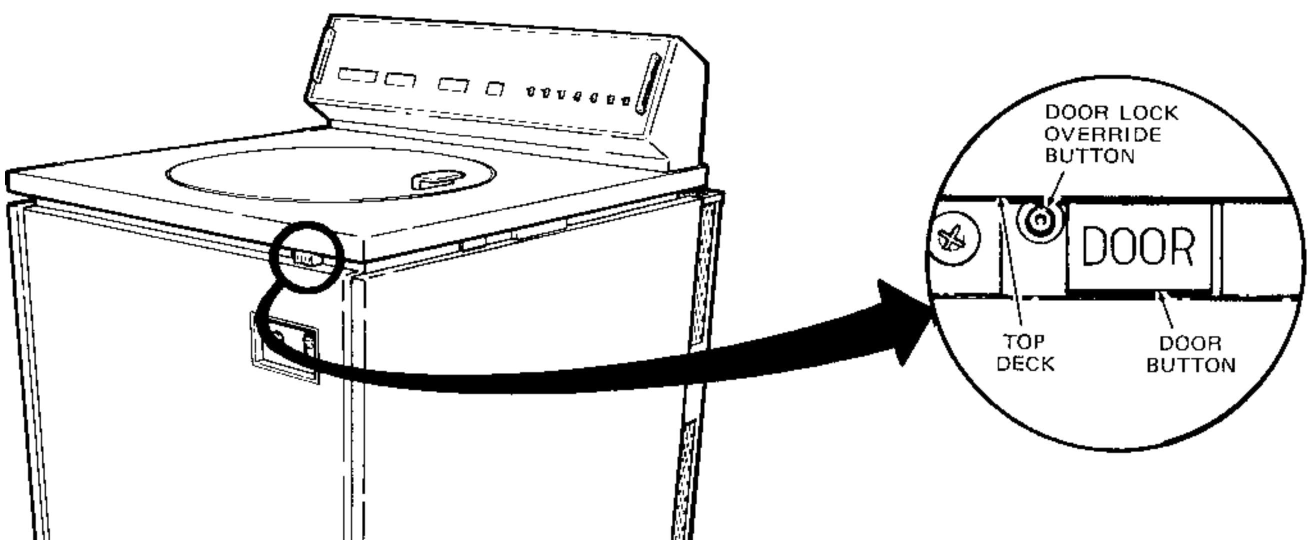


Figure 4-1. Door Latch Override Button Location

Service Decontamination Policy

> **WARNING**
> Because of the characteristics of the samples likely to be processed in this centrifuge, biological or radioactive contamination may occur. Always be aware of this possibility, and take normal precautions. Use appropriate decontamination procedures should exposure occur.

If a centrifuge or rotor that has been used with radioactive or pathogenic material requires servicing by Thermo personnel, either at the customer's laboratory or at a Thermo facility, comply with the following procedure to ensure the safety of all personnel:

1. Clean the equipment to be serviced of all encrusted material and decontaminate it (see Care and Maintenance section of centrifuge or rotor instruction manual) prior to servicing by the Thermo representative or returning it to the Thermo facility. There must be no radioactivity detectable by survey equipment.

The SORVALL® Product Guide contains descriptions of commonly used decontamination methods and a chart showing method compatibility with various materials. The Care and Maintenance Section of the centrifuge or rotor instruction manual contains specific guidance about cleaning and decontamination methods appropriate for the product it describes.

Clean and decontaminate your centrifuge or rotor as follows:

For superspeed floor model centrifuges:

a. Remove rotor from the rotor chamber.
b. Remove, wash, and decontaminate motor sealing gasket and pad.
c. Decontaminate lid, rotor chamber, and drive using an appropriate method.
d. Remove all encrusted material from around the motor and drive assemblies.

For rotors:

Remove tubes, bottles, and adapters from the rotor and decontaminate rotor using an appropriate method. If tubes or rotor caps are stuck in the rotor, or the rotor lid is stuck, notify Thermo representative; be prepared with the name and nature of the sample so the Thermo Chemical Hazards Officer can decide whether to authorize the rotor's return to a Thermo facility.

Do not leave a loaded rotor locked inside a centrifuge that requires servicing. If, with a loaded rotor installed in the chamber, a centrifuge malfunction makes it so that the chamber door will not open by normal means, follow the Emergency Sample Recovery procedure found in your centrifuge operating instructions manual to gain access to the rotor.

2. Complete and attach Decontamination Information Certificate (in the back of your rotor or instrument manual) to the centrifuge or rotor before servicing.

   Decontamination Information Certificates are included with this book. Additional certificates are available from the local Thermo Representative or Field Service Engineer. In the event these certificates are not available, a signed, written statement certifying that the unit has been properly decontaminated, identifying what the contaminants were and outlining the decontamination procedures used will be acceptable.

NOTE The Field Service Engineer will note on the Customer Service Repair Report if decontamination was required and, if so, what the contaminant was and what procedure was used. If no decontamination was required, it will be so stated.

If a centrifuge or rotor to be serviced does not have a Decontamination Information Certificate attached and, in Thermo's opinion presents a potential radioactive or biological hazard, the Thermo representative will not service the equipment until proper decontamination and certification is complete.

If the centrifuge or rotor must be returned to a Thermo facility:

1. Contact your Thermo representative to obtain an Equipment Return Decontamination Form; be prepared with the name and serial number of the centrifuge or rotor and the repairs required.

2. Complete the Equipment Return Decontamination Form and return it to Thermo. Upon receipt of a completed form, a Returned Material Authorization Number (RMA Number) will be issued to you.

3. With the RMA Number clearly marked on the outside of packaging, send the items to the address obtained from your Thermo representative.

CAUTION Do not ship or transport a centrifuge with a rotor installed on the drive spindle. If a centrifuge chamber door cannot be opened using conventional methods, refer to the Emergency Sample Recovery (mechanical override) instructions that are provided in your centrifuge operating manual.

NOTE United States federal regulations require that parts and instruments *must* be decontaminated before being transported. Outside the United States, check local regulations.

If equipment is received at Thermo facilities without a valid RMA Number on the outside of the shipping container and a completed Equipment Return Decontamination Form on file, the equipment will be treated as a potential contamination hazard, and will not be serviced until decontamination certification has been completed. The sender will be contacted for instructions regarding disposition of the equipment in question; all disposition costs will be borne by the sender. If contaminated equipment is received at Thermo facilities, both the carrier and appropriate authorities shall be notified.

APPENDIX

Rotor Information Table

WARNING

The SORVALL® RC-5C PLUS can be used with the SORVALL® rotors that are listed in the table below and on the next page *only*. Use of another manufacturer's rotor can cause rotor failure which could result in personal injury and/or centrifuge damage.

ROTOR	CODE #	MAX SPEED (rpm)	CRITICAL SPEED (rpm)	MAX RCF	K FACTOR [1]	MAX COMPARTMENT MASS (g)	RADIUS MAX (cm)	RADIUS MIN (cm)
SV-288	01	20 000	1 500	40 301	210	50	9.02	6.47
SV-80	02	19 000	1 500	40 968	97	6.4	10.16	8.84
SA-600	04	16 500	950	39 412	793	115	12.96	5.52
SS-34	05	20 000	1 140	47 808	750	115	10.70	3.27
SE-12	06	21 000	1 100	45 959	514	30	9.33	3.81
HB-4	07	13 000	1 100	27 712	1 667	250	14.68	4.82
HS-4	08	7 000	1 000	9 430	4 491	1 035	17.23	7.22
SM-24	09	20 000	1 100	49 461 [2]	456 [2]	27	11.07 [2]	5.38 [2]
TZ-28	11	20 000	900	42 580	612	1 620	9.53	3.62
SH-MT	12	13 730 [3]	1 400	19 141 [3]	657 [3]	36.4	9.09 [3]	5.57 [3]
SH-80	13	20 000	700	45 395	400	78	10.16	5.40
F-28/13	14	19 500	1 200	48 548	294	23	11.43	7.34
F-28/36	15	18 000	1 200	41 366	479	66	11.43	6.18
S-20/36	16	8 000	350	11 510	3 176	156.6	16.10	7.21
S-20/20	17	12 000	350	20 798	1 026	115	12.93	7.21
S-20/17	18	8 000	350	11 860	3 735	130.1	16.59	6.45
SS-34/KSB	19	20 000	1 000	47 808	401	—	10.70	5.68
TZ-28/GK	20	19 000	900	38 428	678	—	9.53	3.62
TZ-28/DL (dynamic loading)	21	20 000	900	42 580	612	—	9.53	3.62
HB-6	23	13 000	1 000	27 617	1 765	164	14.63	4.50
F-28/50	24	19 500	800	48 718	694	115	11.47	4.04
F-20/MICRO	25	20 000	1 200	51 427	187	3.0	11.51	8.57
SA-300	26	21 000	1 100	47 634	812	115	9.67	2.35
SLA-1000	27	16 500	800	35 793	1 725	400	11.77	1.84
SLA-1500	28	14 500	750	31 916	1 579	420	13.59	3.66

1 With maximum allowable volume at maximum speed.
2 Outer row.
3 Maximum speed of rotor is 20 000 rpm; actual maximum speed depends on tubes. Values given are typical for 1.5 ml microtubes.

ROTOR	CODE #	MAX SPEED (rpm)	CRITICAL SPEED (rpm)	MAX RCF	K FACTOR [1]	MAX COMPARTMENT MASS (g)	RADIUS MAX (cm)	RADIUS MIN (cm)
SH-3000 (buckets)	29	4 350	900	3 919	9 500	1 805	18.54	9.11
SLA-3000	30	11 000	500	20 449	2 813	780	15.13	3.94
SH-3000 (microplates)	31	4 350	900	3 175	— [2]	987	15.02	— [2]
SLA-600TC	32	12 500	820	25 656	987	74	14.70	7.99
SLC-4000	33	7 000	400	9 184	7 655	1 500	16.76	2.51
SLC-1500	34	14 000	700	25 862	1 944	420	13.70	3.74
SLC-3000	35	10 000	650	17 604	3 394	780	15.76	4.12
SA-512	36	18 500	1 000	44 040 [3]	438 [3]	30	11.52 [3]	6.37 [3]
SA-800	37	19 500	1 000	42 138	652	162	10.45	4.12

1 With maximum allowable volume at maximum speed.
2 Will vary depending on number and size of microplates.
3 Outer row.

Warranty

Thermo Electron Corporation makes no warranty of any kind, expressed or implied, except as stated in this warranty policy.

The SORVALL® RC-5C PLUS Superspeed Centrifuge is warranted to be free from defects in material and workmanship for a period of one year from the date of delivery. The compressor, condenser, evaporator and all interconnecting tubing are warranted to be free of defects in material and workmanship for a period of five years from the date of delivery. Thermo will repair or replace and return free of charge any part which is returned to its factory within said period, transportation prepaid by user, and which is found upon inspection to have been defective in materials or workmanship. This warranty does not apply to any damage to any instrument resulting from: normal wear and tear; misuse; abuse; use of electrical currents or circuits other than those specified on the plate affixed to the instrument; accident; negligence; failure to follow operating instructions; or use of any rotor other than a SORVALL® rotor intended for use in this instrument.

Thermo reserves the right to change, alter, modify, or improve any of its instruments without any obligation whatsoever to make corresponding changes to any instrument previously sold or shipped.

The foregoing obligations are in lieu of all other obligations and liabilities including negligence and all warranties, of merchantability or otherwise, expressed or implied in fact or by law, and state our entire and exclusive liability and buyer's exclusive remedy for any claim or damages in connection with the sale or furnishing of goods or parts, their design, suitability for use, installation or operation. Thermo will in no event be liable for any special or consequential damages whatsoever, and our liability under no circumstances will exceed the contract price for the goods for which liability is claimed.

Glossary

ARC Automatic Rate Control. An accessory mode that controls the acceleration and deceleration of a rotor to avoid gradient or pellet disturbance. Automatically sets the optimal acceleration and deceleration rate for each rotor.

HOLD A feature that selects a continuous run in place of a run controlled by time in hours and minutes; when it is selected, HOLD keeps (holds) the rotor at the selected run speed until STOP is pressed.

Integrator Mode An accessory mode that allows the user to control a run by an integral value rather than time in hours and minutes. The integral value represents the centrifuge force accumulated over time. The mode is activated by setting the OFF/$\int\omega^2dt$ to $\int\omega^2dt$.

Normal Mode The operation mode that is used to perform most centrifuge runs. The mode is activated by turning the key on the front panel to NORMAL and the OFF/ARC switch and the OFF/$\int\omega^2dt$ switch to OFF.

Overtemperature The maximum estimated sample temperature (MAX) allowed during a centrifuge run; if the temperature in the display exceeds this value, the run will terminate.

RCF Relative Centrifugal Force. An accessory that calculates RCF. The force (*g* force) applied to a suspension of particles during centrifugation relative to the force that the earth's gravity would have on them. It is related to speed (rpm) by this equation: RCF=11.17 x radius (in cm) x $(\text{rpm} \div 1000)^2$.

Rotor Code The number assigned to each rotor model compatible with the centrifuge. The code determines how the centrifuge calculates RCF and controls speed and temperature for the rotor.

Zonal Mode An accessory mode that allows the user to dynamically load the SORVALL® TZ-28 Zonal Rotor. The mode is activated by turning the key on the front panel to ZONAL.

Abbreviations

A Ampere

ARC Automatic Rate Control

LED Light-Emitting Diode

RCF Relative Centrifuge Force (*g* force)

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(continued)

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CHINA
Tel.: 86 21 6865 4588
86 10 5850 3588

INDIA
Tel.: 91 22 5542 9494

JAPAN
Tel.: 81 45 453 9220

OTHER ASIA PACIFIC COUNTRIES
Tel.: 852 2885 4613

AUSTRIA
Tel.: 43 (1) 801 40 0

BELGIUM
Tel.: 32 2 482 30 30

FINLAND
Tel.: 358 9 329 100

FRANCE
Tel.: 33 1 69 18 77 77
33 2 28 03 20 00

GERMANY
Tel.: 49 6184 90 6940
49 6103408 1012

ITALY
Tel.: 39 02 95 05 91

NETHERLANDS
Tel.: 31 76 571 4440

SPAIN or POTUGAL
Tel.: 46 8 585 777 50

SWITZERLAND
Tel.: 41 (1) 454 12 12

UNITED KINGDOM or IRELAND
Tel.: 44 870 609 9203

Other EUROPE, MIDDLE EAST, or AFRICA
Tel.: 49 6184 90 6940
33 2 28 03 20 00

RUSSIA/CIS
Tel.: 7 095 225 11 15

UNITED STATES of AMERICA
Tel.: 1 800 522 7746
1 866 984 3766

CANADA or LATIN AMERICA
Tel.: 1 800 522 7746
1 866 984 3766

In Other Countries:
Contact your local **SORVALL**®
products distributor or agent.

DANS LES AUTRES PAYS:
Contactez votre concessionnaire
local des produits **SORVALL**®
ou leur representant.

IN ANDEREN LÄNDERN:
Wenden Sie sich an Ihren
örtlichen **SORVALL**®-vertreter.

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RC-5C *Plus*
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2.0 Installation

Section 2: INSTALLATION

After you receive your centrifuge, inspect it for damage before using it. The RC-5C PLUS centrifuge must be installed in a location that meets all of the location and electrical requirements specified in this section. Installation instructions are on page 2-2.

2-1. Inspection

As soon as you receive your RC-5C PLUS you should carefully inspect it for any shipping damage that may have occurred. If you find any damage, please report it immediately to the transportation company and file a damage claim, then notify DuPont. If any parts are missing, contact one of the DuPont district offices or the local representative of SORVALL® Products. You will find a list of offices on the back cover of this manual.

2-2. Location Requirements

The location of the centrifuge should be carefully considered because free air circulation is very important for the centrifuge to function properly. To allow adequate air circulation, locate the centrifuge in an area that will allow 10 cm (4 inches) clearance between the wall and the sides of the centrifuge and has an ambient temperature within 15°C to 38°C. If the inlet air temperature is above 25°C, the centrifuge may not maintain low temperatures at high speeds.

When the centrifuge is situated at its operating location, install it as specified later in this chapter.

2-3. Electrical Requirements

CAUTION The centrifuge can be damaged if it is connected to a line voltage that varies more than ±10% of its nominal value. Check the voltage before plugging the centrifuge into any power source. DuPont is not responsible for improper installation.

The appropriate single-phase power source must be available to plug the centrifuge into. Check the nameplate on the back panel of the centrifuge to determine the electrical configuration of your centrifuge, which is one of the following:

240 V, 50 Hz, 30 A[1]
230 V, 60 Hz, 30 A[1,2]
220 V, 50 Hz, 30 A[1]
208 V, 60 Hz, 30 A[1,2]
200 V, 60 Hz, 30 A[1]
208 V, 60 Hz, 50 A[1]
230 V, 60 Hz, 50 A[1]

1CSA and UL approval is applied for.
2 Instruments shipped to Canada are shipped without a power cord (see paragraph 2-5 g).

To connect the centrifuge to a voltage other than what is specified on the nameplate (including polyphase), it will have to be rewired and its power cord may have to be replaced. Contact DuPont to have a Field Service Engineer do the rewiring.

The centrifuge is equipped with a 3-wire power cord with a 3-prong grounded plug (NEMA 6-30P) that fits NEMA receptacle 6-30R or equivalent. (Centrifuges shipped to Canada are supplied with a power cord to fit a NEMA 6-50R receptacle or equivalent.) For connection to other receptacles, the power cord may have to be replaced. Follow local electrical codes.

CAUTION The centrifuge can be damaged if it is connected to a line voltage that varies more than ±10% of its nominal value. Check the voltage before plugging the centrifuge into any power source. DuPont is not responsible for improper installation.

If the line voltage varies by more than ±10% of its nominal value, it may damage the centrifuge. *Read the CAUTION.*

The main power ON/OFF switch is a 30 A circuit breaker; therefore, a separate line disconnect switch is not needed unless required by local codes.

2-4. Installation

To install the centrifuge:

1. *If you are installing a new centrifuge,* remove any packaging.
2. Roll centrifuge into position. Open the chamber door by following the emergency sample recovery procedure in Section 12, paragraph 12-1.
3. Install a rotor WITHOUT its lid. Place a level on the center hub of the rotor.

CAUTION The centrifuge can be seriously damaged if it is operated when it is not level.

4. Turn the two leveling feet (refer to figure 1-1) with the 9/16-inch wrench provided until they bear weight. Alternately turn the feet with the wrench to raise or lower the feet until the centrifuge is level . Remove the level. ***Read the CAUTION.***
5. Plug the centrifuge into the appropriate electrical outlet.

2-5. Rewiring the Centrifuge

When converting either a 60 Hz or 50 Hz centrifuge to any voltage, connect wire 210 on TB101 as follows:

Input Voltage	TB101 Terminal
200	TB101-3
208	TB101-4
220	TB101-5
230	TB101-6
240	TB101-6

When converting a centrifuge from either 60 Hz to 50 Hz or from 50 Hz to 60 Hz, refer to the chart above. For 50 Hz conversion, move wire #143 to TB101-3; for 60 Hz conversaion move wire #143 to TB101-6.

Refer to system schematic, figure 6-1 and the system wiring diagram, figure 6-2.

Conversion to Single Phase Permanent Wiring

WARNING Tampering with the high voltage electrical circuits in this centrifuge can cause severe electrical shock: this procedure must be performed by a qualified electrician only.

This procedure applies to instruments shipped to Canada.

Connect the incoming power lines to the centrifuge as follows:

1. Set the main circuit breaker, POWER switch, to OFF.
2. Disconnect the power cord from the power supply.
3. Remove the right cabinet panel from the centrifuge.
4. Connect the safety ground wire to the lug connector marked GND ⏚, figure 2-1 (on the next page).
5. Connect the incoming ac power wire to TB102-1.
6. Connect the ac power return wire to TB102-2.
7. Reinstall right cabinet panel.

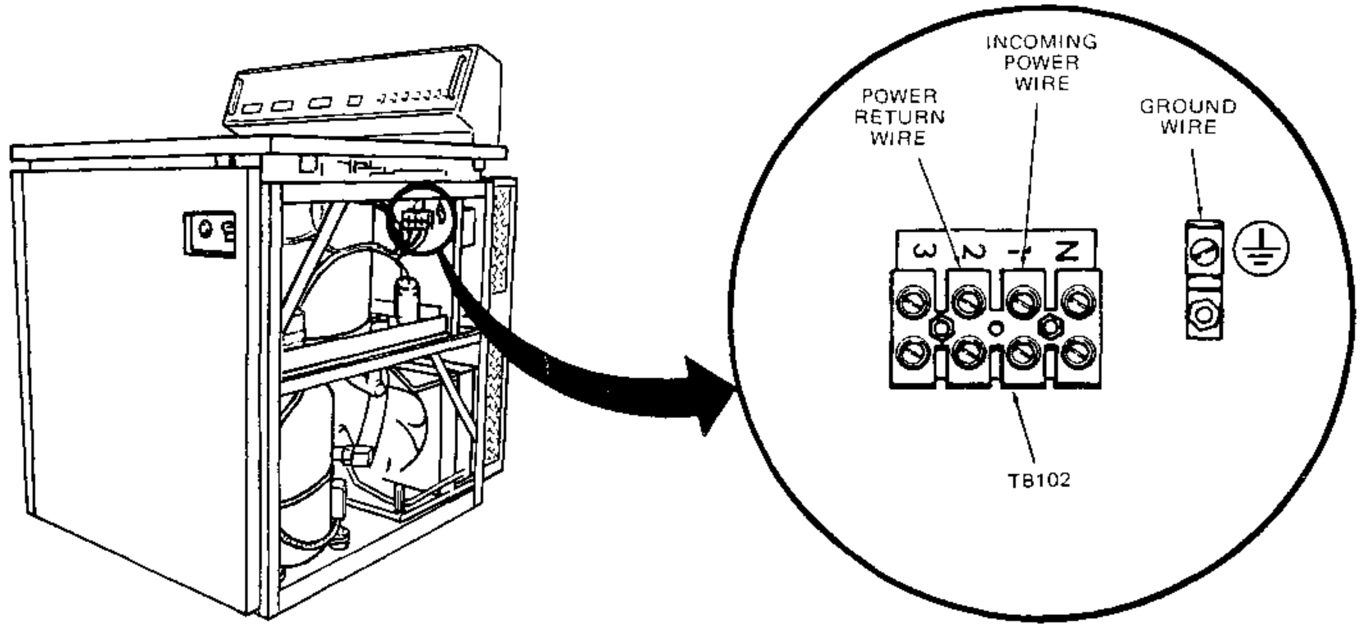

Figure 2-1. Single Phase Permanent Wiring

2-6. Test Run Procedure

After completing installation/rewiring of the centrifuge, perform a test run.

1. Ensure that the centrifuge is connected to a power supply and that the main circuit breaker, POWER switch, is set to ON.

2. Set up the centrifuge as follows:

   a. Set SPEED RPM switches to 10 000.

   b. Set TEMP °C RUN switches to 04.

   c. Set ACCESSORY MODE switches to OFF.

   d. Set TIMED/HOLD switch to HOLD.

   e. Set OFF/BRAKE switch to BRAKE.

f. Set the key switch to NORMAL.

g. Install SS-34 rotor in centrifuge.

3. Close the centrifuge chamber door.
4. Press the START switch.
5. Verify the following:
   - The rotor acceleration rate is slow and even.
   - The set speed is maintained within 1%.
   - The set temperature is maintained within 1°C.
6. Set the TIME HRS and MIN switches to 00 01 (one minute).
7. Set the TIMED/HOLD switch to TIMED.
8. Verify that the rotor starts to decelerate after one minute.
9. Press the STOP switch.
10. When the rotor stops, remove it from the centrifuge.
11. Record the test run parameters.

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3.0 Preventative Maintenance

RC-5C+ Preventative Maintenance

Routine Maintenance:

This section contains procedures for the routine, preventive, and corrective maintenance of the RC-5C Centrifuge. The routine and preventive maintenance procedures are performed on a scheduled basis to ensure that the centrifuge functions properly.

Warning:

- **Because of high voltage in the centrifuge, untrained personnel must not attempt to test or repair any electrical circuits in it. Service personnel must read and understand the theory of operation before servicing the centrifuge.**

- **To remove the potential of electrical shock, set the main circuit breaker, POWER switch, to OFF and disconnect the main power cord from the power source. The terminals of the circuit breakers are always energized when the power cord is connected.**

- **If the centrifuge has been used with radioactive or pathogenic samples, there is the possibility that radioactive or biological contamination may have occurred. Appropriate precautions and decontamination procedures must be followed.**

ROUTINE MAINTENANCE:

1. Inspect the centrifuge and rotors weekly for the following:

   - Signs of wear, pitting and corrosion (due to caustic samples or cleaning agents).
   - Encrusted biological deposits.
   - Accumulation of dust (condenser).
   - Ice build up in the rotor chamber.

2. Clean, replace, or repair as required.

DEFROSTING THE ROTOR CHAMBER:

Defrost the rotor chamber whenever ice build up in the chamber is evident.

1. Connect the power cord to a power supply.

2. Set the main circuit breaker, POWER switch, to ON.

3. Install a rotor in the rotor chamber and close rotor chamber door.

4. Set up centrifuge as follows:
   a. Set TEMP °C RUN switches to 25 and TEMP °C MAX switches to 30.
   b. Set SPEED RPM switches to 3000, set TIMES HRS and MIN switches to 00 05.
   c. Press START switch.

5. When rotor stops, open chamber door and inspect for ice. If chamber is defrosted, remove rotor and wipe dry. Remove moisture from chamber with a cloth or sponge. If chamber is not defrosted, repeat step 5.

6. Set main circuit breaker, POWER switch, to OFF.

CLEANING AND INSPECTING THE ROTOR:

1. Wipe rotor with a clean cloth after each use.

Caution:

Chlorides are extremely harmful to aluminum alloy rotors. Prevent any contact of chloride with the rotor or corrosion will result. Corrosion attacks the inside as well as the outside of the metal through barely detectable surface cracks. The rotor can be weakened without visible warning signs.

2. Clean the rotor weekly or immediately if a spill has occurred.
   a. Fixed angle or vertical rotor: Wash the rotor with a mild non-alkaline household detergent and water. Rinse and allow to dry.
   b. Swinging bucket rotor:
      1) Wash the rotor body and swinging buckets with a mild non-alkaline household detergent and water. Rinse and allow to dry.
      2) Clean and lubricate the rotor pins and the mating bearing surfaces of the bucket that ride on the pins. Obtain rotor cleaning kit (Cat. No. 12259) for cleaning materials and instructions.

         a) Cut a cleaning pad into 1/2 inch (12 mm) wide strips, saturate a pad strip with acetone or alcohol.
         b) Wrap the strip around a rotor pin and put it back and forth. Move the strip around to clean the pin completely. Repeat this process for each rotor pin.
         c) Saturate another pad strip and thoroughly clean the mating bearing surfaces of each bucket.
         d) Lubricate the bucket bearing surface with Grease, PN 64172.

      3) After the cleaning is completed, place the buckets on the rotor pins and check that all buckets swing freely. Worn or damaged pins or

bucket may cause binding. Careful examination will determine which part is defective and must be replaced.

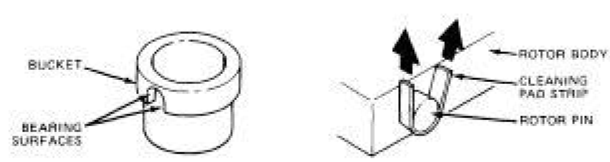
Warning:

The buckets must swing freely for proper rotor operation. Do not run the rotor if any bucket binds on its pins.

3. Inspect rotor before each use for signs of wear and corrosion of swinging bucket rotors, inspect bucket bearing trunnion pins for wear.

Warning:

Do not use rotors showing signs of wear or corrosion.



Clean and Lubricate Swinging Bucket Rotor

CLEANING THE CABINET AND DRIVE SPINDLE:

The entire centrifuge must be kept clean. Clean the enameled cabinet panels weekly with a commercial wax based cleaning product. Clean the top deck surface and door with a household detergent and water. Use a brush to remove ground in dirt. Immediately afterwards, rinse thoroughly with water, especially if using solvent based or chlorinated cleaners for removal of difficult stains. The spindle must be kept clean so the rotor does not stick to it. Wipe it with a soft cloth each time before the rotor is installed, warm water may be used for cleaning when the chamber is defrosted. A clean undamaged surface is essential for proper rotor installation and removal.

CLEANING THE CONDENSER FINS:

Accumulation of dirt, dust, and debris on the condenser fins reduces the efficiency of the refrigeration system. The condenser fins are located at the rear of the centrifuge. To maintain refrigeration efficiency, check for accumulation weekly and clean the condenser fins with a brush or vacuum cleaner at least once a month. The fins bend easily, use care when cleaning.

TESTING THE LEDS, ADVISORY MESSAGES, AND DIAGNOSTIC INDICATORS:

The LEDs, advisory messages, and diagnostic indicators on the front control panel should be tested daily during start up. Each LED digit has seven segments: if even one segment does not work, an incorrect reading can be displayed.

1. Turn the main circuit breaker, POWER switch, to OFF.

2. Set ROTOR CODE switches to 00. Disregard all other switch settings.

3. Turn the main circuit breaker, POWER switch, to ON. Watch the front control panel and make sure the displays, indicators, and advisory messages light as follows:

   - The number 8 should be shown in each digit space of each display.
   - The minus sign should light in the TEMP °C display.
   - All ten backlit advisory messages should light.
   - Diagnostic indicators 1 through 12 should light.
   - All other indicators should light except the RCF indicator. To test the RCF indicator, press the RCF switch.

4. If necessary, replace the LED Display Board, or replace the advisory message and diagnostic light bulb.

LUBRICATION OF COMPONENTS:

All components are pre "lubricated and require no further lubrication. The refrigeration unit is hermetically sealed and the ball bearings in the gyro action drive assembly and the centrifuge motor are permanently lubricated.

PREVENTIVE MAINTENANCE

The preventive maintenance checks of the centrifuge and rotors are performed on service visits as specified by the service contract or requested by the user. In the cases where no service contract exists, the preventive maintenance procedures must be performed by qualified service personnel selected at the discretion of the user. The inspection and cleaning procedures that should be done routinely by the operator are found under “Routine Maintenance”. Check that the routine maintenance procedures are being performed. Discuss any problems with the operator.

Caution:

Before performing the maintenance procedures, ensure that the centrifuge and rotors are not contaminated. The centrifuge and rotors must be certified free of biological or radioactive contamination. A Decontamination Information Certificate must be filled out by the customer. Do not service or repair any equipment for which the proper decontamination procedures have not been performed.

If the preventive maintenance checks reveal existing and/or potential problems with the centrifuge, perform the appropriate corrective maintenance procedures.

Use the Preventive Maintenance Checklist included at the end of this section to record the completion dates of procedures, pertinent data, and any comments relating to the maintenance and operation of the centrifuge and rotors.

CENTRIFUGE ENVIRONMENT CHECK:

The centrifuge requires adequate ventilation and proper environmental conditions to function properly. To provide adequate air circulation, the centrifuge must be located in an area that allows a 10 cm (4 inch) clearance between any wall and the all sides of the centrifuge. The centrifuge operates in a temperature between 15°C and 38°C. If the inlet air temperature is above 25°C, the centrifuge may not maintain low temperatures at high speeds.

Note:

If ambient temperature exceeds 25°C, the centrifuge may not maintain the preset temperature during high speed runs.

CENTRIFUGE AND WALL OUTLET GROUND CONTINUITY CHECK:

Check that the ground lug of the electrical plug is properly grounded and is shorted to the frame of the centrifuge. Check that the ground "lug of the outlet (wall receptacle) is properly grounded.

Warning:

Before the centrifuge is serviced, ensure that the centrifuge and wall receptacle are checked for ground continuity. Failure to do so can result in a serious electrical shock.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the power supply.

3. Check centrifuge ground continuity as follows:
   a. Set a DVM to the lowest resistance scale.

b. Attach one probe of the DVM to ground lug on the power cord.
c. Touch the other probe of the DVM to the chassis of the centrifuge. The meter should show less than 0.1 ohms.

4. Check wall outlet ground continuity as follows:
   a. Set the DVM to Vac scale.
   b. Measure each side of the line to the ground receptacle. The voltage should be "115 Vac. If no voltage is measured, the receptacle is not properly grounded.
   c. Measure the voltage from line to line. The voltage should match the voltage found on the centrifuge name plate (208 to 230 vac).

5. Remove the DVM and probes.

CONDENSER FINS CHECK:

Examine the condenser fins. To remove accumulated dirt and dust, refer to "Routine Maintenance" section of the Service Manual.

ROTOR INSPECTION:

1. Inspect all rotors (including swinging bucket rotors) for corrosion and wear.

2. Inspect bucket bearing surface and rotor trunnion pins for wear. Clean and lubricate the pins and the underside surfaces of the bucket area that ride on the pins.

3. Inspect the rotor lid locking stud.

4. Clean and inspect any Sorvall® RX rotor covers. If lid does not fit on the rotor smoothly replace the pertinent components.

5. Inspect 0-rings (if applicable).

6. Record the serial numbers of all rotors inspected and any problems relating to the rotors.

ROTOR CHAMBER CHECK:

Defrost the rotor chamber whenever ice build up in the chamber is evident.

1. Connect the power cord to a power supply.

2. Set the main circuit breaker, POWER switch, to ON.

3. Install a rotor in the rotor chamber and close rotor chamber door.

4. Set up centrifuge as follows:
   A. Set TEMP °C RUN switches to 25 and TEMP °C MAX switches to 30.
   B. Set SPEED RPM switches to 3000, set TIMES HRS and MIN switches to 00 05.
   C. Press START switch.

7. When rotor stops, open chamber door and inspect for ice. If chamber is defrosted, remove rotor and wipe dry. Remove moisture from chamber with a cloth or sponge. If chamber is not defrosted, repeat step 5.

8. Set main circuit breaker, POWER switch, to OFF.

LEDS, ADVISORY MESSAGES, AND DIAGNOSTIC INDICATORS CHECK:

The LEDs, advisory messages, and diagnostic indicators on the front control panel should be tested daily during start up. Each LED digit has seven segments: if even one segment does not work, an incorrect reading can be displayed.

1. Turn the main circuit breaker, POWER switch, to OFF.

2. Set ROTOR CODE switches to 00. Disregard all other switch settings.

3. Turn the main circuit breaker, POWER switch, to ON. Watch the front control panel and make sure the displays, indicators, and advisory messages light as follows:

   - The number 8 should be shown in each digit space of each display.
   - The minus sign should light in the TEMP °C display.
   - All ten backlit advisory messages should light.
   - Diagnostic indicators 1 through 12 should light.
   - All other indicators should light except the RCF indicator. To test the RCF indicator, press the RCF switch.

4. If necessary, replace the LED Display Board, or replace the advisory message and diagnostic light bulb.

DOOR LATCH MICROSWITCH CHECK AND LUBRICATION-

1. Connect the power cord to the mains supply.

2. Set the main circuit breaker, POWER switch, to ON.

3. Check that the centrifuge does not start with the chamber door open as follows:

    a. Set up the centrifuge as follows:

        1) Set TEMP °C RUN switches to 4.
        2) Set SPEED RPM switches to 3000.
        3) Set TIME HRS and MIN switches to 00 05.
        4) Set key switch to NORMAL.

    b. Press the START switch. The centrifuge does not start and the DOOR advisory message lights.

4. Set the main circuit breaker, POWER switch, to OFF.

5. Lubricate the door latch by placing a few drops of oil on the locking bolt.

NORMAL MODE RUN CHECKS:

This procedure checks the following run conditions when the centrifuge is in a normal operating mode:

NO ROTOR indicator. Diagnostic 6.
ROTOR CODE advisory message.
HOLD advisory message.
Maximum motor current draw on acceleration.
Maximum speed.
Compressor cycle times.
Accumulated run time.
RCF indicator and value.
Brake time.
Timer.
Compressor steady state current draw.
OVERTEMP advisory message.
$\int$2dt indicator, advisory message, and value.

1. Set main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the power supply.

3. Remove all cabinet panels.

4. Connect the power cord to the mains power supply.

5. Set main circuit breaker, POWER switch, to ON.

6. Check the NO ROTOR indicator. (Diagnostic 6).

   a. Close the chamber door.
   b. Press the START switch.
   c. Verify that the NO ROTOR indicator. (Diagnostic 6), lights and the centrifuge shuts off.

7. Open the chamber door and install an SS-34 rotor (any other available rotor could be used).

8. Close the chamber door.

9. Set up the centrifuge as follows:

   a. Set the TEMP °C RUN switches to 02 and TEMP °C MAX switches to 20.
   b. Set the SPEED RPM switches to 10 000.
   c. The TIME HRS and MIN switches have no specific setting.
   d. Set the ROTOR CODE to 05 for an SS-34 rotor (other codes may be used to match the rotor that is used).
   e. Set the OFF/ARC and the OFF/$\int$2dt switches to OFF.
   f. Set the TIMED/HOLD switch to HOLD and the OFF/BRAKE switch to BRAKE.
   g. Set the key switch to NORMAL.
   h. Press the START switch. Record the time the START switch was pressed.

10. Verify that the HOLD advisory message lights and that at zero speed the ROTOR CODE advisory message lights and flashes for approximately 5 seconds.

11. Verify that after 5 minutes the temperature has stabilized at the preset run temperature +1°C.

12. Check the maximum motor current and the maximum speed as follows:

    a. After the temperature has stabilized at 2°C for 5 minutes, set the SPEED RPM switches to 20 000 or the maximum allowable speed for the rotor in use, refer to Rotor Table.
    b. While the rotor accelerates, measure the motor current draw on the ammeter.
    c. On centrifuges using brush motors verify that the maximum motor current draw on acceleration is 16.5 amps. If necessary, calibrate the motor current limit. This step can be disregarded on centrifuges using brushless drives.

d. On centrifuges using brush motors verify that the rotor attains the preset maximum run speed ±1%. If necessary calibrate the top speed. This step can be disregarded on centrifuges using brushless drives.

13. Verify that the compressor cycles at 2°C. If the compressor does not cycle at 2°C, check for the following conditions:

    Ambient temperature above 25°C.
    Low refrigerant charge.
    Faulty start or run capacitor.
    Air leak in door or gyro seals.
    Air blockage at condenser coils.
    Condenser fan non-functional.
    If necessary, refer to Troubleshooting for Refrigeration System.

14. Check the accumulated run time.

    a. Refer to the time recorded in step 10. h. and calculate the accumulated run time.
    b. Verify that the accumulated run time that is displayed equals the calculated run time in step 15.a.

15. Check the RCF indicator and value.

    a. Press the RCF switch.
    b. Verify that the RCF indicator lights (green).
    c. Verify that the value shown in the SPEED RPM RCF display is the correct RCF value for the rotor in use.

NOTE:
ROTOR CODE switches must be set for rotor in use.

16. Check the braking time.

a. Press the STOP switch. Record the braking time: the time from when the STOP switch is pressed until the SPEED display shows zero rpm.
b. Verify that the braking time is within the specified value range for the rotor and speed in use: (see rotor speed chart)

Rotor	Maximum Speed	Critical Speed
SLA-3000	11,000 rpm	500 rpm
SLA-1500	14,500 rpm	750 rpm
SLA-1000	16,500 rpm	800 rpm
SA-600	16,500 rpm	950 rpm
SA-512		
SA-800		
SLA-600TC	13,000 rpm	1,100 rpm
F28-50	19,500 rpm	800 rpm
SS-34	20,000 rpm	1,140 rpm
SA-300	21,000 rpm	1,000 rpm
F28-36	18,000 rpm	1,200 rpm
SM-24	20,000 rpm	1,100 rpm
SE-12	21,000 rpm	1,100 rpm
F28-13	19,500 rpm	1,100 rpm
F20-MICRO	20,000 rpm	1,100 rpm
SH-3000	4,350 rpm	900 rpm
SH-3000M	4,700 rpm	900 rpm
HS-4	7,000 rpm	1,000 rpm
HB-6	13,000 rpm	1,000 rpm
HB-4	13,000 rpm	1,100 rpm
S20-36	8,000 rpm	300 rpm
S20-20	12,000 rpm	350 rpm
S20-17	8,000 rpm	350 rpm
SH-80	20,000 rpm	1050 rpm
SV-288	20,000 rpm	1,500 rpm
SV-80	19,000 rpm	1,500 rpm
TZ-28	20,000 rpm	
SLC-1500		
SLC-3000		
SLC-4000		

17. Check the timer as follows:

    a. Set the TIME HRS and MIN switches to 00 01, one minute.
    b. Set the TIMED/HOLD switch to TIMED.
    c. Press the START switch.
    d. Verify that the centrifuge shuts off after one minute.

18. Check compressor steady state current draw as follows:

    a. Remove amprobe from wire #145 and attach to wire #206 of K101, compressor.

b. While the compressor is running, verify that the steady state current draw is less than or equal to 12 amps. The compressor reaches steady state current draw approximately 10 seconds after start up. If necessary, refer to Troubleshooting for Refrigeration System.

19. Check the OVERTEMP advisory message as follows:

    a. Ensure that an SS-34 rotor or other high speed rotor is installed and precooled to 10°C.
    b. Set the TEMP °C RUN switches to 10 and TEMP °C MAX switches to 13.
    c. Set the TIME HRS and MIN switches to 00 20.
    d. Start the centrifuge. After the centrifuge speed stabilizes at the rotor's set speed set the MAX temperature to 1°C lower than the displayed temperature.
    e. Verify that the OVERTEMP advisory message lights and the centrifuge shuts off.

20. Check the ∫2dt indicator, advisory message, and value as follows:

    a. Set the OFF/ ∫2dt switch to ∫2dt.
    b. Set the TIMED/HOLD switch to TIMED.
    c. Set the TIME COEF and EXP switches to 50 06. The value is interpreted as COEF and EXP: 50 x 10 °6.
    d. Set the SPEED RPM switches to 5000.
    e. Verify that the ∫2dt indicator lights (green).
    f. Press the START switch.
    g. Verify that the ∫2dt advisory message lights.
    h. Observe the TIME/∫2dt display: Verify that the centrifuge shuts off when the preset integral value is accumulated.

ZONAL MODE RUN CHECKS:

Check the following run conditions when the centrifuge is in a zonal operating mode:

Automatic rate controlled (ARC) slow start.
Automatic rate controlled (ARC) slow stop.

1. Connect the power cord to the mains power supply.

2. Set the main circuit breaker, POWER switch, to ON.

3. Open the rotor chamber door and install an SS-34 rotor.

Warning:

Clear the top deck of the centrifuge. The centrifuge chamber door is open and the rotor is spinning during the first part of this procedure. Loose materials could fall into the chamber and cause damage to the operator and/or centrifuge.

4. Set up the centrifuge as follows:

    a. Set the TEMP °C RUN switches to 02 and TEMP °C MAX switches to 20
    b. Set the SPEED RPM switches to 1000.
    c. The TIME HRS and MIN switches have no specific setting.
    d. Set the ROTOR CODE switches to 05 for an SS-34 rotor. If a SS-34 is not available use the highest speed rotor that is available and use the correct rotor code for that rotor.
    e. Set the OFF/ARC switch to ARC and the OFF/BRAKE switch to BRAKE.
    f. Set the key switch to ZONAL.
    g. Press the START switch.

Note:

In the zonal mode, the centrifuge can be run with the chamber door open at speeds less than or equal to 1400 rpm. If the chamber door is open at speeds above 1400 rpm the run in process is terminated.

5. The automatic rate controlled slow start to 500 rpm is enabled and the rotor begins to accelerate within 30 seconds. After 500 rpm is attained, the rotor accelerates at a normal rate to the preset run speed, 1000 rpm. Observe the SPEED RPM display to verify the automatic rate controlled slow start: the acceleration rate from zero to 500 rpm is less than the acceleration rate from 500 rpm to the set speed, 1000 rpm.

6. Close the rotor chamber door when the rotor reaches the preset run speed, 1000 rpm.

7. Set the SPEED RPM switches to 5000. The rotor accelerates to 5000 rpm.

8. Press the STOP switch when the rotor reaches preset run speed, 5000 rpm.

9. The rotor decelerates with braking to 700 rpm. The automatic rate controlled slow stop is enabled at approximately 700 rpm. Observe the SPEED RPM display to verify the automatic rate controlled slow stop: the deceleration rate from set speed, 5000 rpm, to 700 rpm is greater than the deceleration rate from 700 rpm to zero rpm. The SPEED RPM display shows the slow down at approximately 300 - 400 rpm.

10. Exit the ARC mode as follows:

a. Set the OFF/ARC switch to OFF.
b. Press the START switch to end the ARC logic.
c. Press the STOP switch. The centrifuge decelerates to zero rpm.

MECHANICAL CHECKS:

Check the following systems and conditions, which relate to the mechanical operation of the centrifuge: Motor and gyro-action drive system, Refrigeration system, Physical balance, imbalance detector, and OUT OF BALANCE advisory message.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the power supply.

3. Remove the front, rear, and right cabinet panels.

4. Check the refrigeration system as follows:

   a. Check all fittings for refrigerant leaks with a halogen leak detector, if the temperature is not maintained white running.

   b. Check the start and run capacitors if high compressor current is detected. Use a digital volt meter and follow the manufacturer's instructions for checking the capacitors or use an analog volt-ohm meter as follows.

Warning:
The start and run capacitors in the capacitor assembly retain high voltage charges. Be sure they are completely discharged before removing or performing maintenance in that area. Discharge the start and run capacitors by grounding one terminal of the capacitor through a load resistor.

1) Remove cover of capacitor box (if present).

2) Disconnect the leads from the start and run capacitors and remove capacitors from the box.

3) Connect the leads of a volt-ohm meter to the start capacitor.

4) Set volt-ohm meter to the lowest resistance scale.

5) Reverse the polarity of the leads. If the needle of the meter deflects toward zero ohms and returns to an infinite resistance reading, the start

capacitor is good. If the needle does not deflect, increase the resistance scale setting of the meter and repeat step 5) until the meter deflects. If the needle does not deflect after increasing the resistance scale to the maximum setting, the capacitor should be replaced.

6) Connect the leads of the volt-ohm meter to the run capacitor and perform steps 4 and 5.

5. Check the motor and gyro-action drive system as follows:

   a. Remove the motor and gyro-action drive from the centrifuge.
   b. Check the gyro-action drive bearings for excessive noise or roughness.
   c. Check the gyro-action drive bushings in the spindle and at the bottom of the housing for wear or signs of deterioration.
   d. If the centrifuge has a brush type motor check the motor brushes. If the centrifuge utilizes a brushless drive system skip to step #6.

      1) Remove the motor brushes from the motor: inspect brushes and replace if the length is less than 14 mm (9/16 inch).
      2) If new brushes are not installed, replace the brushes, maintaining the original orientation with the curvature of the commutator.
      3) Check brush spring tension:
         - Major brush spring: 20 ± 2 oz.
         - Minor brush spring: 2 ±0 oz.

   e. Check the commutator for wear, the surface should be shiny.
   f. Check the gyro-action drive seal/rubber boot and cushion/foam padding for cracks or tears and replace if necessary.
   g. Reinstall the drive motor and gyro-action drive system.

6. Reinstall the front, rear, and right cabinet panels.

7. Connect the power cord to a power supply.

8. Check the centrifuge balance.

   a. Ensure that the front locking stabilizers are down and that the centrifuge is level and stable on all points. The weight should be evenly distributed to all points to avoid high speed rotor buffeting.
   b. Check the imbalance detector and OUT OF BALANCE advisory message.

Thermo
ELECTRON CORPORATION

RC5C/5C PLUS

Preventative Maintenance Checklist

SORVALL
Heraeus

Account Name:		**Instrument Model:**	
Account Address:		**Serial Number:**	
Report Number:		**Date:**	

Rotor Inspection

- ☐ Check for corrosion or excessive wear
- ☐ Lubricate buckets and trunnions
- ☐ Inspect Rotor locking stud

Mechanical

- ☐ Lubricate door latch
- ☐ Interlock Microswitch Adjustment
- ☐ Refrigeration leaks
- ☐ Door screws secure
- ☐ Replace constant current brake standoffs

Motor and Gyro

- ☐ Gyro bearings
- ☐ Gyro bushings
- ☐ Lower coupling
- ☐ Replace motor brushes
- ☐ Commutator
- ☐ Tachometer
- ☐ Replace motor mounting hardware
- ☐ Inspect and replace tapered spindle pins
- ☐ Motor ground continuity
- ☐ Replace the gyro seal and cushion
- ☐ Brush warning

Pre-Run Checks

- ☐ Ground Continuity
- ☐ Condenser fins/ Air Filter cleaned
- ☐ Rotor Chamber (defrost)
- ☐ Door interlock and latch
- ☐ Door seal
- ☐ Line Voltage ______VAC
- ☐ Door spring functional
- ☐ Ambient conditions

Electronic Checks

- ☐ Display segments on power up
- ☐ Compressor current______amps
- ☐ Current Limit
- ☐ Maximum speed
- ☐ Motor cooling fan(5C+ only)
- ☐ Speed Control calibration
- ☐ Set Temperature calibration
- ☐ Compressor cycle time
- ☐ Timer function
- ☐ Overtemperature
- ☐ Brake function
- ☐ Overspeed

Imbalance

- ☐ Centrifuge stable and level
- ☐ Centrifuge shuts off with proper weight

Comments:

S.R. Signature ____ **Date:**

RC-5C *Plus*
Table of Contents

4.0 Theory of Operation

RC-5C *Plus* Brush Motor Drive System:

This section describes the circuits of the RC-5C *Plus* Centrifuge drive system. Refer to Section 8 for schematics.

General Description:

The direct drive system of the RC-5C *Plus* Centrifuge contains a universal motor, a gyro-action drive, and a control system.

The motor is a series wound universal motor and is directly coupled to the gyro-action drive with a helical coupling which compensates for any concentricity difference between the motor and the gyro.

The gyro is designed to self center and to compensate for minor rotor imbalance. This is accomplished using two flexed planes. One is located in the gyro cone and is a rotating flexure, the other is stationary and consists of three rubber mounts located between the drive and the frame.

The motor armature is balanced to ensure quiet operation with a minimum of vibration over the range of operating speeds and to extend the life of the motor brushes. The bearings are isolated from the gyro housing by two rubber isolators to maintain low noise and extend the life of the bearings.

An imbalance detector is mounted between the drive plate and the frame plate. The detector consists of a piezoelectric crystal mounted between two rubber disks. The signal from the crystal is proportional to the imbalance forces transferred through the gyro-action drive.

The control system consists of a saturable reactor; an optical tachometer for closed loop speed control; the display and central circuits, including microprocessor software; and the slow start and brake circuits.

Conditions for Operation:

The following conditions must be met when the START switch is pressed.

- The main circuit breaker, POWER switch, is set to ON.
- The key switch is set to the NORMAL or ZONAL mode.
- A rotor is installed in the rotor chamber.
- The correct rotor code is set in the ROTOR CODE switches.
- The centrifuge chamber door is dosed and latched in the normal mode.
- The TIMED/HOLD switch is set correctly.
- The TEMP °C RUN and MAX switches are set to the correct value.
- The SPEED RPM switch is set to a value greater than zero.

- The ∫ω2Dt mode, if used, has the correct coefficient and exponent values set.
- The OFF/BRAKE and OFF/ARC switches are set correctly.
- No override or fault conditions exist.

Once the START switch is pressed the centrifuge accelerates to the preset speed and remains in the run mode for the preset time period unless the run is interrupted manually by the operator or automatically buy a protective circuit. In either case, the centrifuge returns to an idle mode.

Motor Drive Circuitry:

When the main circuit breaker, POWER switch, is set to ON, the initialization circuitry resets the microprocessor. The initialization circuitry is made up of the portions of the circuit connected to pins 1 and 2 of analog comparator 17. This circuit places a logic zero on pin 40 (RES) to reset the microprocessor through the action of voltage reference source Q7 and the R/C delay circuits (R65, C46). This circuitry also accepts a reset (RES) command from the pushbutton S3 on the Microcomputer Board to reset the microprocessor.

The logic level command signal RUN RY from the Microcomputer Board on J32 pin 13 to the High Voltage Interface Board is used to activate the run relay: this switches the motor from a braking circuit to a running circuit configuration. RUN RY and FAULT M are AND'ed by Z10-11 such that the RUN RY command signal and the absence of a fault memory, FAULT M, signal are required for the operation of the run relay. If no fault memory condition exists, driver amplifier Z2-9 in series with the motor overtemp switch in the motor will drive the run relay in response to a run relay command RUN RY. In addition, LED DS4 will light on the High Voltage Interface Board to indicate a run relay command.

The analog control input signal SR DRIVE from the Microcomputer Board on J32 pin 17 controls the saturable reactor during the high drive portion of both the slow and normal runs, and controls the slow start drive circuit in the slow ramp portion of a slow start run.

When used for slow ramp control in a slow start run, the SR DRIVE signal varies the dc threshold at Z5-14 pin 12 to vary the pulse width to the slow start driver circuit via P101.

When controlling the saturable reactor, the signal flow is through resistors R18 and R67, and onto amplifier Z5-1 pin 3. Z5-1, Q1, and R61 form a voltage controlled current regulator which directly controls the level of current delivered to the control winding of the saturable reactor via P101 pin F.

High Voltage Interface Board NAND GATE Z10-6 allows the slow start mode to disable the saturable reactor drive. Resistor R19 forms a voltage divider allowing a current limiting feedback signal to immediately reduce drive current by 5% without waiting for computer action.

Motor Overtemp Circuitry:

This circuitry consists of a thermal switch on the field windings and is in series with the run/brake relay windings. The switch is normally in the closed position. In the case of excessive motor heat, the switch opens and drops out the run relay: the drive is disabled.

Brake Circuitry:

When energized, the brake assembly provides dc to the field of the drive motor. The energized field causes the rotating motor to operate as a generator producing a dc output voltage across the armature. At high speeds, the two shunt transistors, Q1 and Q2, are biased off placing the generated dc across the cone resistor, R6. As speed drops, the dc generated from the motor also drops until the voltage across R2 and R3 reaches a point where Q1 and Q2 begin to conduct. This provides a sustained high braking rate into the low speed region. Because of the heat generated by Q1 and Q2 when they are conducting, a thermostat switch S1 switches 230 Vac to the compressor fan. The compressor fan provides cooling air for the brake assembly.

Brush Warning Circuitry:

The logic level signal BRUSH WARN is generated by the High Voltage Interface Board and advises the Microcomputer Board via J32 pin 12 that a brush wear warning condition has been detected. A brush wear warning is initiated when a brush warning contact is closed in the main drive motor and 4 to 18 Vac is placed on P101 pin T. This turns on NPN transistor Q3 which places a logic zero on J32 pin 12. LED DS12 lights to indicate the presence of a brush warning condition.

Imbalance Signal Conditioning Circuitry:

If the rotor is unbalanced, the piezoelectric acoustical detector wi11 generate a voltage that is applied to the Microcomputer Board, J3 pin 5. Utilizing RC circuitry and the dual differential comparator Z22, the incoming voltage (from the imbalance detector) is compared to a preset voltage that is adjusted and maintained by R40. If the result of the two voltage comparison indicates an imbalance, the comparator will generate an imbalance port control signal IMBAL from Z22 pin 7 and send it to versatile interface adapter Z5 pin 18. This port control signal controls bi-directional port B, pins 10 through 17, and causes a FAULT M signal to be generated on pin 12: this disables run relay K103 which disables the drive.

Door Interlock Circuitry:

In the normal run mode, the door latch switch S102 and the door switch S103 must be closed in order to operate the centrifuge. In this case, a logic level signal DOOR CLD is sent to the Microcomputer Board from the High Voltage Interface Board indicating the door is closed and latched. In standby, the Microcomputer Board sends the logic level command TJDOR SOL to the High Voltage Interface Board. This energizes the solenoid coil L102, engages the solenoid, and enables the door to be opened, when a start command is issued, solenoid L102 is disengaged and prevents the door from opening.

In the zonal mode, zonal switch S101 generates the logic level signal ZONAL SM on the High Voltage Interface Board and sends it to the Microcomputer Board. In response, the Microcomputer Board continues to send the DOOR SOL signal until the speed exceeds 1500 rpm.

Speed Control and Related Circuitry:

Speed control, rpm indication, zero speed and overspeed detection are all determined in conjunction with the tachometer signal conditioning circuitry.

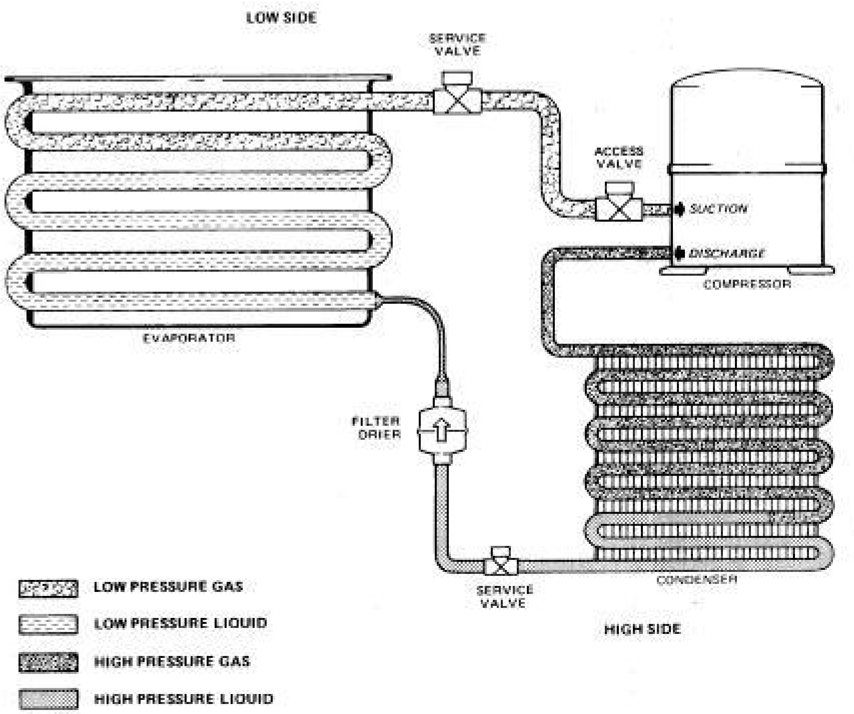
The low current signal TACH located on J3 pin 3 is sent to the Microcomputer Board from the Optical Pick-Up Board. It is converted to a voltage of 0 to12 Vac by transistor Q3 and sent to Z22, a dual differential comparator. Here it is compared to a preset voltage of +6 Vdc, the output of which (Z22 pin 1) passes through a low pass filter and then Z24, a hex Schmitt trigger inverter. Z24 then provides a control port signal to be supplied to Z5 pin 40. The output is also passed to the master stave flip flop Z26 which in turn creates two outputs. One is used for the portable tachometer set-up and the other provides a control port signal on Z5 pin 39 and to data port pin 16. The generation of the 3 port control signals (Z5 pins 40, 39, and 16) is required for the rpm indication, speed control, zero speed, overspeed detection, and signal conditioning for external tach calibration instruments (portable tachometer).

RC-5C *Plus* Refrigeration System:

This section describes the theory and operation of the refrigeration system of the RC-5C *Plus* Centrifuge.

The refrigeration system is a low temperature hermetically seated unit that uses HP-62 (R-404A) refrigerant. The stainless steel evaporator acts as the rotor chamber. Refrigeration control is achieved by cycling the compressor on and off as required.

Refrigeration Cycle:



The refrigerant, HP-62 (R-404A), enters the compressor as a low pressure, heated gas. It is converted into a high pressure, high temperature gas by the compressor and in this state it is pumped to the condenser. A fan circulates cooling air through and around the condenser tubing and heat is released to the atmosphere. As the refrigerant loses heat it becomes a high pressure liquid. The filter/dryer cartridge absorbs foreign particles and water that can enter the subsystem and reduce the refrigeration efficiency. The capillary tube, which controls the low pressure side of the system, restricts the flow of the refrigerant causing a pressure drop across its "length. Refrigerant pressure is high between the output of the compressor and the input to the capillary tube, and low between the output of the capillary tube and the suction part of the compressor. The compressor output side is the high pressure side, the suction side is the low pressure side. Once the required temperature is reached the microcomputer stops the compressor. The refrigeration cycle is started again when the temperature exceeds the required value.

Condensing Assembly Circuit:

The temperature control circuit signals the refrigeration cycle to start by energizing the compressor relay, K101. This solid state 90 amp relay requires an operating voltage of 3 to 30 Vdc, which is controlled by driver amplifier Z2 pin 2.

The logic level command signal, COOLRY (Cool Relay), is used to activate the compressor relay and run the refrigeration system. It originates from the Microcomptuer Board and is sent to the High Voltage Interface Board via J32 pin 7. On the High Voltage Interface Board, the driver amplifier Z2 pin 2 controls the 24 Vdc circuit which drives the compressor relay. It is here that LED DS-3 lights to indicate a response to the COOLRY command signal which is then sent via J101 pin 20 to energize the compressor relay, K101. When energized, the solid state relay allows 230V to be supplied to the compressor and fan.

Temperature Control Circuit:

There are two temperature sensors used in the rotor chamber: one measures chamber air temperature, the other chamber floor temperature. Both sensors are mounted in the floor of the rotor chamber. The air temperature sensor is the most critical and requires calibration. The floor temperature sensor is used only to anticipate rates of temperature change and close calibration is not required.

The sensors are two terminal integrated circuit (IC) temperature transducers that produce an output current proportional to absolute temperature. Utilizing a supply voltage of +12 V, the transducers act as high impedance, constant current regulators. A constant current passes through the transducer and an increasing temperature is detected as an increasing voltage in the circuit.

On the Microcomputer Board the voltages from the transducers are converted to a digital value. This digital temperature value, the digital value of the preset run temperature (as set by the operator using the TEMP °C RUN switches on the front control panel), and the rotor parameters are used mathematically to derive the temperature shown in the TEMP °C display of the front control panel and are analyzed to determine whether or not the COOLRY signal is to be generated to activate the refrigeration system.

The logic level signal SSEL (Z5 pin 19) is used to select one of the two temperature sensors for interrogation. The selection of the sensor to be read is under software control and each sensor is selected for 0.5 seconds. Depending on which logic level is on Z5pin 19, 12 ±1 Vdc are placed on J3-2 (floor sensor) or J3-1 (air sensor). The sensor not interrogated is disabled with 0.2 ± 0.2 Vdc.

An analog to digital (A/D) converter, Z20, is used to convert the analog data (3 sequential 4 BCD bit nibbles) from the temperature sensors to digital data for the microprocessor, Z1. The TEMP signal coming from the selected temperature sensor enters the board at J3 pin 10 and is converted from a constant current signal to a voltage signal by flowing through 10K resistor R36. Using voltage reference Q2, amplifier Z21 generates a variable reference on pin 14 and can be adjusted by R34. The resulting voltage is then buffered by Z21 pin 7, and fed into the A/D converter input, Z20 pin 11. The data output lines (DO through D3) of Z20 are connected to the low order 4 bits of the data bus (BDO through BD3) thus driving addresses $0220 through $022F. Output lines MSD, LSD, NSD (Most, Least, Next Significant Digit) are connected to the data bus (BD4 through BD6) only during address $022E. The software is programmed to ignore the low order four data bits for all addresses in the $0220 through $022F range, except for $022E. During $022E, 4 BCD bits of data plus identification as Most, Next, or Least Significant Digit, are delivered to the microprocessor. The slower, asynchronous nature of the A/D converter is taken into consideration in the software, which protects against acceptance of erroneous transition data.

1 Description of Brush motor / Drive Control Signals/System

1.1 SRDRIVE

The RC-5C Plus centrifuges with serial numbers ******** and below are driven by a Universal brush-type motor. Drive current to the motor is controlled using a saturable reactor connected in series with the motor armature. Control-voltage to the reactor saturates the core in positive relation to the applied control voltage. This control voltage is referred to as SRDRIVE.

The SRDRIVE voltage is continuously variable from 0-2.5VDC. A maximum applied voltage results in a maximum saturation of the reactor core and a maximum current through the drive motor. The SRDRIVE is initially adjusted to –2.5V. This means that the control voltage swing on SRDRIVE will be 0 to -2.5V.

When ARC (Automatic Rate Control) is selected from the front panel control, acceleration from 0-512 RPM and deceleration from 768 to 0 RPM is performed at a programmed rate. When this mode is active, the control system commands less torque by providing a lower signal value on the SRDRIVE line.

1.2 SLOW_RY

This signal, is asserted when the motor is to be placed in a coast mode or when the rotor has stopped moving altogether. It is also active concurrently with RUN_RY at the beginning of an ARC run.

1.3 RUN_RY

The main control system asserts a signal called RUN_RY (for Run Relay) when drive is to be applied. When RUN_RY is false the drive is braking or coasting down to 0. Which of these two conditions is determined by the state of the front panel switch Brake and by the speed of the rotor (i.e. The rotor speed will be either within or outside of the controlled rate zone.). Braking in is accomplished by effectively shorting the motor leads with a resistor.

1.4 ARC Mode Operation

When the front panel switch is placed in the ARC position before the start of a run, the following sequence occurs upon activation of the START switch:

1. RUN_RY signal becomes active.
2. SLOW_RY signal remains active for about 0.5s.
3. SRDRIVE signal ramps up until rotor starts to move.
4. SRDRIVE backs off until desired rate of acceleration is reached.
5. SRDRIVE modulates to maintain desired rate of acceleration until speed reaches 512 RPM.
6. SRDRIVE increases in proportion to desired torque.

On the deceleration portion of the run, the following sequence is followed:

1. Normal deceleration (either coasting or regenerative braking) occurs down to 768 RPM. RUN_RY is inactive. If we are coasting, SLOW_RY is active.
2. System reasserts RUN_RY when speed is detected below 768 RPM.
3. System commands torque sufficient to accelerate back to 768 RPM by modulating SRDRIVE signal.
4. System modulates SRDRIVE to achieve desired rate of deceleration to 0 RPM.
5. System reasserts SLOW_RY when rotation stops.

2 Operation of Replacement Control Actuator System

The system for driving the brushless motor uses all the signals from the brush motor system. In the following subsections, we describe the interface between the brush motor control system and the brushless motor drive box. Each possible set of control parameters is named and the resultant actions of the brushless interface are described.

2.1 Liveness Protocol

There are two processors on the drive interface board. One (Drive PIC) is responsible for computing and applying torque through the drive system. The other processor (Safety PIC) monitors the condition of the Drive PIC and halts drive operation if a fault is detected. Because the Safety PIC itself could come to be a sleeping fault if it is not monitored, we implement a liveness protocol by which the Drive and Safety PICs monitor each other's ability to respond to external stimuli on a continual basis. The two processors use a pair of handshaking lines to implement the protocol. The Safety PIC starts operation in the SEIZING state, while the Drive PIC starts in the LOCAL state. From this point, the processors proceed in lockstep as long as no errors are detected.

2.1.1 LOCAL State

When a processor is in the LOCAL state, it has exclusive access to the shared I2C bus. The handshaking output line is held in a seized condition. The I2C bus is the interface for access to the message RAM, the motor Ke memory, and the motor temperature sensor.

2.1.2 HOLDING State

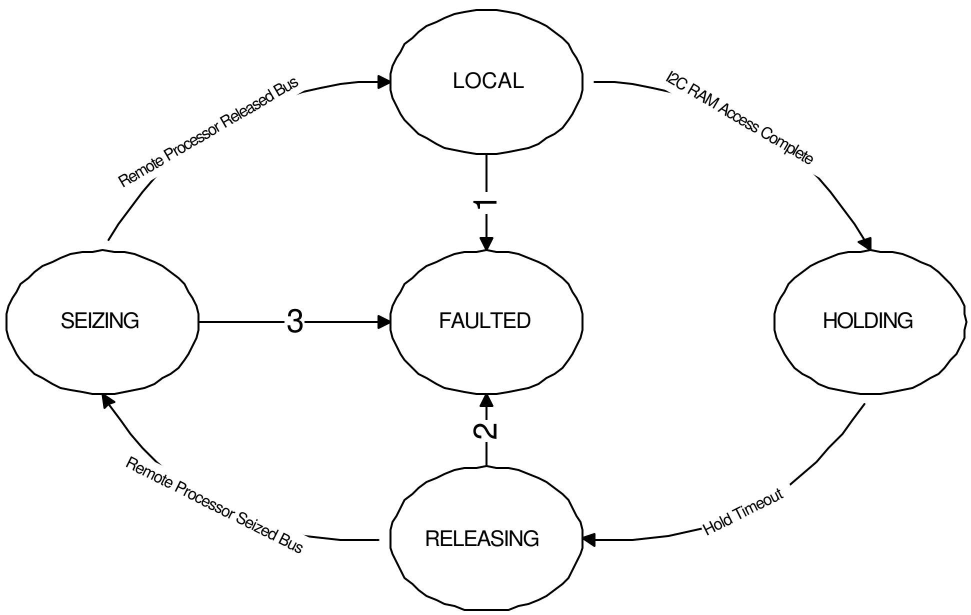
When a processor is in the HOLDING state, it continues to reserve exclusive access to the shared I2C bus by keeping the handshaking output line in seized condition. This condition is preserved for 0.50 seconds so that the other processor is guaranteed enough time to detect that its counterpart has seized the bus.

2.1.3 RELEASING State

When a processor is in the RELEASING state, it gives up access to the shared I2C bus by changing the handshaking output line to the released condition. The processor now begins polling its counterpart's handshaking output line to see if it asserts a seized condition on that line. This condition is preserved until the releasing timeout period elapses or a seized condition is detected from the counterpart processor's line.

2.1.4 SEIZING State

When a processor is in the **SEIZING** state, it attempts to obtain exclusive access to the shared I2C bus by polling its counterpart's handshaking output line for a released condition. The processor continues polling its counterpart's handshaking output line until the seizing timeout period elapses or a released condition is detected from the counterpart processor's line.



1. Tach Disagree, Motor Overtemp, Message Error
2. Timeout
3. Timeout

Figure 1 Liveness Protocol

2.1.5 Inputs From Microcomputer Control

The following signals are signals from the previously existing microcomputer control system. These signals are directly monitored by the PIC which uses these signals to perform its control function. Using the hardware resources of the new drive interface board (formerly the high-voltage interface board) and the drive box, the PIC replaces the control functions of the old system. The signals described in this section are the entire universe of control input signals carried over from the old design into this new design.

2.1.5.1 RUN_RY

This signal is TRUE when the control system is commanding that torque be applied in the forward direction to the motor. When the signal is FALSE, torque may be commanded (depending on other conditions) in the reverse direction or not at all.

2.1.5.2 SLOW_RY

This signal is active when no torque is commanded in either direction (i.e. coast). It also becomes active when the rotor stops. This signal is also active for a short period of time after the START switch on the front panel is depressed when the ARC switch is in the ARC mode position.

2.1.5.3 SRDRIVE

This analog voltage level is directly proportional to the current that should be applied to the motor drive.

2.1.5.4 FAULT_M

This is a latched signal that indicates a fault has been detected by the main control processor. This signal gates the RUN_RY signal so that if a fault has been set, the PIC cannot see RUN_RY become TRUE. This signal is not directly observed by the PIC. It is only indirectly observed by its gating function on the RUN_RY signal.

2.1.6 DBOX Interface

The DBOX interface is a new interface with this design. The PIC controller drives all output-control signals on this interface.

2.1.6.1 RUN

When TRUE, allows torque to be applied to the motor in proportion to the input PWM signal. When FALSE, no torque can be applied regardless of the PWM signal.

2.1.6.2 RESET/EN

Forces a master hardware reset for the entire DBOX on the falling edge. Holds drive disabled as long as it is 0. Drive begins recovery after rising edge of this signal and is ready for service three seconds after the rising edge.

2.1.6.3 DIRECTION

Logic signal determines direction of applied torque. The sense of this signal is such that a logic 1 causes applied torque to aid forward rotation.

2.1.6.4 PWM

This pulse width modulated signal could be varied between 0% (no drive current) and 100% (maximum drive current) duty cycle. The design prevents the duty cycle from exceeding a value that would provide torque that could cause us to exceed the Maximum Credible Accident (MCA) conditions established for the existing RC-5C+. We have employed the torque curve upon which MCA was based to construct a new torque curve that does not permit the user, through any misapplication of front panel settings, to induce conditions that exceed the established MCA. We expect this new torque curve to permit improved acceleration and deceleration times. We implement this torque curve by tethering the PWM duty cycle according to the following rules:

1. From 0 to 8,600 rpm duty cycle is limited to a value which will permit 14 inch-lbs of torque.
2. From 8,100 to 15,000 rpm duty cycle is limited to a value that will not cause a torque greater than 11 inch-pounds. Since the drive box and motor combination will apply 15 inch-pounds of torque if PWM duty cycle is 100% and motor $K_e = K_{eMin}$, our maximum applied PWM will be given by ((11/15) * (K_{eMin} / K_e) * 1023), where 1023 represents 100% duty cycle.
3. From 15,000 rpm on up, the maximum duty cycle is teathered so as to limit torque to that given by the formula: Torque Max = 11 – ((speed-15,000)/1000)*0.583 inch-pounds. In other words, the torque curve decreases linearly from 15,000 rpm at a rate of –0.583 inch-pounds/1000 rpm. Maximum PWM is given by ((Torque Max/15)*(K_{eMin}/ K_e) * 1023).

2.1.6.5 #FAULT

When the RUN signal is TRUE, a logic 0 on this pin indicates a fault condition has been detected by the drive box. When the RUN signal is FALSE, this pin indicates that the drive box is not attempting to supply torque to the motor. If RUN is asserted TRUE and no faults are present, #FAULT should show a FALSE condition within 10ms. If RUN is asserted FALSE, then #FAULT should assert TRUE within 10ms.

2.1.6.6 Motor Overtemperature Input

Positive True logic when asserted by drive box indicates motor is in overtemp condition.

2.1.6.7 Dynamic Brake Output

Logic 1 applied to this pin causes a resistance to be placed across the motor leads Which causes the back EMF to provide braking force.

2.1.7 LED Indicators

The LED indicator bar is a carryover from the previous design. It is described here for the purpose of explaining additional indicators and providing a convenient reference. The following list provides descriptions or cross-references to the sections describing the meaning of each LED.

1. 5V PWR LED: Lit when 5V is present on board.
2. SLOW: See section 1.2 SLOW_RY
3. DOOR SOL: This light is lit when the door solenoid is energized allowing the door to be opened.

4. COOL: This light is lit when the cooling compressor is running.
5. RUN: See section 1.3 RUN_RY
6. DOOR: This light is lit when the door is open.
7. ZONAL: This light is lit when the ZONAL mode of operation is active.
8. FAULT_M: See section 2.1.5.4 FAULT_M.
9. A4: See section 2.1.7 **LED Indicators**
10. MOTOR COOL: See section 3.3.3 **Extended Run Time for Motor Cooling Fan**
11. A5: See section 2.1.7 **LED Indicators**

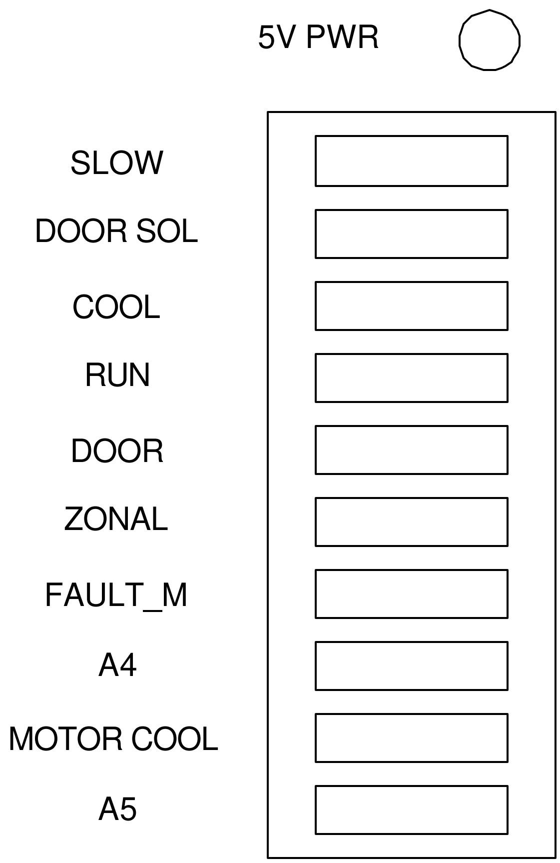


Figure 2 LED Indicator Bar

2.1.8 Drive PIC Controller

The Drive PIC controller monitors all the signals described above in the existing drive system plus some new signals. The most fundamental task of the PIC is to control the Drive Box interface by supplying:

1. PWM signal proportional to the commanded torque and the characteristics of the motor
2. Direction signal to command the direction in which the torque is to be applied
3. Run command signal to command either torque or coast operation

The PIC also detects direction of rotation and several fault conditions and responds accordingly.

2.1.9 PWM Monitor (Safety) PIC

This PIC is dedicated to the task of ensuring that output torque commanded by the drive box is tethered to our specified limits. This PIC computes the maximum permissible PWM using the same calculations as the Drive PIC but using a separate tachometer signal. This PIC monitors the PWM output of the Drive PIC and if the maximum value is exceeded, turns off the RUN and EN signals to the drive box.

Both PIC controllers participate in a monitoring protocol so that if either one fails to respond to the other or detects a significant difference between the reported speed of the two PICs during operation, the PIC which detects this condition removes drive signals from the drive box interface and ceases operation.

2.1.10 Direction Tach Signals

Two Hall-Effect sensors separated by 30^o of motor shaft rotation provide the direction tachometer signals. The PIC monitors these signals and extracts motor rotational speed and direction. The number of timer ticks in a complete rotation determine the speed. Direction is determined by reading the value of sensor two when sensor one transitions from low to high or high to low. If sensor two is the same as sensor one after a transition, then rotation is forward. If it differs, then rotation is in the reverse direction.

2.1.11 I2C Serial EEPROM

This I2C memory module contains information associated with the particular motor. I2C address of device is 0xA8 for write and 0xA9 for read. In addition to the data, the memory contains a LRC data value for data integrity detection on the. This is computed by taking the bit sum of all data in the memory. Data in the memory includes the Motor K_e Constant, Maximum PWM, and the revision level of the software. The LRC is stored at byte address 7. This arrangement is shown in the following table.

Address	Contents
0	Firmware Revision Number
1	Motor K_e MSB
2	Motor K_e Byte 2
3	Motor K_e Byte 1
4	Motor K_e LSB
5	Motor Maximum PWM MSB
6	Motor Maximum PWM LSB
7	XOR(0:6)

2.1.11.1 Motor K_e Constant

This value is stored in an I2C memory module associated with the particular motor. Output PWM can be scaled according to this constant. A lower K_e value implies more drive current is required to generate a given amount of torque. Value range is specified in reference. Data is stored in standard IEEE single precision floating point format (4 bytes). Data is located starting at byte memory address 0 which holds the MSB. The value is arranged as follows:

```
MSB                        LSB
Exponent Sign     Mantissa
|        |Bit
EEEEEEEE SMMMMMMM MMMMMMMM MMMMMMMM
```

2.1.11.2 Maximum PWM

This data is stored in the same memory part holding the Motor K_e Constant described in 2.1.11. This is a 16-bit integer stored starting at memory address 4 which holds the MSB. For historical reasons, it is computed by:

MaxPWM = $(11/15)*(K_{eMax} / K_e)*(1023)$

The software extracts the integer representation of K_e from this number at run time.

2.1.11.3 Firmware Revision Level

This number is used to ensure that the Maximum PWM is computed in the manner expected by the PIC firmware. The PIC firmware compares this number against its stored revision level and aborts if there is a difference. This number starts at zero and can go no higher than 255.

2.1.12 I2C Serial Static RAM

This I2C memory module is used for passing tachometer messages between the Drive and PWM Monitor PICs. Access to this memory is shared by a protocol using I/O pins on each PIC connected to the other PIC. Each PIC has a location to which it writes its own tach data and from which it reads the other PIC's tach data.

2.1.12.1 Message Format

The message passed between the safety and drive PIC has the same format for each processor. It is described as follows:

0	Source Identifier	Safety PIC 0xA5 Drive PIC 0x5A Error 0x12
1	Speed MSB	MSB of 16 bit representation of remote speed in RPM
2	Speed LSB	LSB of 16 bit representation of remote speed in RPM
3	Test State	TESTPROCEED TESTINACTIVE TESTCOMPLETE
4	Remote Data	From Safety PIC last Source Identifier read
5	Remote Duty Cycle MSB	From Safety PIC last duty cycle detected
6	Remote Duty Cycle LSB	From Safety PIC last duty cycle detected
7	Message Checksum	LRC (bitwise exclusive OR)of message bytes

2.2 Input / Output Signal Combinations

2.2.1 Acceleration without Rate Control

Inputs will be as follows:
- RUN_RY asserted TRUE at PIC input pin
- SRDRIVE providing a voltage in the range of 0-3VDC
- FAULT M = 0

Outputs will be as follows:
- RUN to DBOX = 1
- DIRECTION signal to DBOX signals forward
- RESET/EN to DBOX = ENABLE
- PWM to DBOX proportional to SRDRIVE and computed PWM Max.

2.2.2 Acceleration with Rate Control

Inputs will be as follows:
- RUN_RY asserted TRUE at PIC input pin
- SLOW_RY asserted TRUE at PIC input pin for 0.5s at beginning of run
- SRDRIVE providing a voltage in the range of 0-2.5VDC
- FAULT M = 0

Outputs will be as follows:
- RUN to DBOX = 1
- DIRECTION signal to DBOX signals forward
- RESET/EN to DBOX = ENABLE
- PWM to DBOX proportional to SRDRIVE

2.2.3 Deceleration with Braking and without Rate Control

Inputs:
- RUN_RY = FALSE
- SRDRIVE ignored
- SLOW_RY will be FALSE
- Direction/Tach Sensors Indicating Rotation in Primary Direction
- Direction/Tach Sensor Providing two Pulses per Revolution

Outputs:
- RUN to DBOX = 1
- DIRECTION to DBOX signals reverse
- RESET/EN to DBOX indicate ENABLE
- PWM applied to DBOX inversely proportional to speed indicated by tach sensor down to boundary of constant torque and constant horsepower.

Design note:
As speed approaches 0, the amount of applied PWM must be reduced to avoid driving the rotor into reverse rotation. Once the control system senses 0 rpm, the SLOW_RY signal is asserted to the PIC. Any time the PIC sees SLOW_RY it commands the DBOX to supply no torque in either direction (i.e. a coast condition, RUN = 0). Before the rotor actually reaches 0 rpm we will cease

applying torque opposed to rotation. Initial design intent is to remove PWM (take to 0) and remove the RUN signal once we detect rpm<=50.

2.2.4 Deceleration with Braking and with Rate Control while Operating Outside of the Controlled Rate Range

Behavior is exactly the same as without rate control.
Design note:
At the point where we change from braking to controlled deceleration, we change over from torque opposed to rotation to a lesser torque applied in the direction of rotation. To accomplish this changeover properly, we follow these steps:

1. While braking, continually monitor the RUN_RY signal from the control system.
2. When RUN_RY becomes TRUE deassert the RUN signal.
3. Change PWM value to that commanded by SRDRIVE.
4. Change DIRECTION to forward.
5. Reassert RUN signal.

There is an important distinction to make here between transition from braking to running in general and the transition between these states that is due to a controlled rate of deceleration. When we detect that RUN_RY has become true when we were in a braking or coasting condition at around 768 RPM, we assume that a controlled rate of deceleration from 768 RPM to 0 RPM is required. This is a change from the old system in that there is a particular sequence of events that could present these conditions without controlled deceleration being requested (i.e. operator could press the START switch when the centrifuge is decelerating). We are going to ignore this possibility and treat the condition uniformly as a rate-controlled deceleration request.

2.2.5 Deceleration with Braking and with Rate Control while Operating Within the Controlled Rate Range

This condition calls for torque to be applied in the forward direction in sufficient measure to overcome frictional braking forces in excess of those required to achieve the desired rate of deceleration. This gives us a case that looks just like acceleration, but with a relatively low value for SRDRIVE coming from the main control system. This translates into a very low value for applied PWM. We may provide different gain factors to our calculation of PWM for controlled deceleration, controlled acceleration, and full acceleration.

2.2.6 Deceleration without Braking and with Rate Control while Operating Outside of the Controlled Range

This is a coasting condition. Inputs:

- RUN_RY = FALSE
- SLOW_RY = TRUE
- SRDRIVE ignored

Outputs:

- DIRECTION = FORWARD

- RUN = FALSE (this means coast to the DBOX)
- RESET/EN = ENABLE
- PWM proportional to SRDRIVE (ignored by DBOX)

Design Note:
When we change over from the uncontrolled to the controlled range, two signals from the main control system will change:
1. SLOW_RY will become FALSE
2. RUN_RY will become TRUE

The response from the PIC will be to reassert the RUN signal to the DBOX while continuing to provide a PWM signal directly proportional to the SRDRIVE signal. See above design note.

2.2.7 Deceleration without Braking and with Rate Control while Operating Within the Controlled Range

This is exactly the same as described in 2.2.5.

3 Drive PIC Firmware Design

This section describes the program for the Drive PIC microcontroller and how it performs the actions described above. First, we describe the sequence of control actions leading to initiation of motion, coasting, and braking. Second the top-level design is described in terms of the task and interrupt structure. Next we describe the actions required for each possible set of operating conditions. Finally, we place the actions in the context of the operating software (i.e. Describe each ISR and polling operation and the data structures upon which they act.).

3.1 Drive State Operational Sequence

This section describes each possible set of operational events for every possible operational state. This is first divided by states and then subdivided into events.

Note: When a Fault condition is propagated, the PWM duty cycle is immediately set to 0 and the control loop is aborted with a message to the console. The fault signal is also propagated to the main control system. The processing of that signal is outside the scope of this document.

3.1.1 TESTING

This state exists when the Drive PIC and the Safety PIC are performing a test to determine whether the Safety PIC is capable of shutting down the Drive Box. The drive PIC enters this state when the processor starts up and after it begins coasting to a stop below 100 RPM. In this state, the Safety PIC and the local software program step through the following sequence:

1. When the Safety PIC detects that the Drive PIC is in TESTING state, it disables the drive box enable. When it detects PWM duty cycle is less than a constant value (say 8) it informs the drive PIC to proceed with the test.

2. When the Drive PIC detects the instruction to proceed from the Safety PIC, it asserts the RUN signal to the Drive Box and begins a ten-millisecond wait.
3. When ten milliseconds have elapsed, the Drive PIC tests the FAULT signal from the Drive Box. If the signal is 0, the test passes, the Drive PIC removes the RUN signal, sends a message to the safety PIC, and waits four seconds. Otherwise the Drive PIC asserts a fault, takes all driving signals away from the Drive Box, and terminates execution.
4. When the Safety PIC detects the signal that the test has passed, it removes the disable condition that it asserted in step 1 and continues with its messaging protocol with the Drive PIC.
5. Because a message must reach the other PIC within 1 second and it takes three seconds for the Drive Box to recover after the disable is released, four seconds is enough time for the Drive PIC to wait after it sends the test-complete message to the Safety PIC. After this time interval, the Drive PIC can enter the QUIESCENT state.

3.1.2 QUIESCENT

This state exists when the PIC processor has completed the TESTING state and has not yet seen any signals that cause it to transition to any other state. This state persists as long as RUN_IN is FALSE. In this state the polling loop runs continually. RUN_IN and fault conditions are monitored.

3.1.2.1 RUN_IN Detected

This commands motion to start. SRDRIVE is used to calculate PWM output, RUN_OUT, and FORWARD are asserted to the drive box and the PIC program moves to the RUNNING state.

3.1.3 RUNNING

This state exists once RUN_IN has been detected and persists as long as RUN_IN is present. In this state, the polling loop continues to run and monitor RUN_IN and Fault conditions as well as read the SRDRIVE signal and output calculated PWM signal to the drive box.

3.1.3.1 RUN_IN Negated

This commands a change in drive control depending upon system variables. Detection of RUN_IN == FALSE while in the RUNNING state causes us to negate RUN_OUT and moves us to the COASTING state.

3.1.3.2 Fault Detected

When a Fault condition is detected in the RUNNING state, we negate the RUN_OUT signal to the drive box (coast), propagate the Fault condition to the control system and enter the TERMINATE state. We will not escape the TERMINATE state without a control system reset.

3.1.3.3 COAST_IN Detected

When the system has undergone a transition from the QUIESCENT state to the RUNNING state, there exists the possibility that RUN_IN and COAST_IN are simultaneously true (happens for about ½ second at the beginning of an ARC run). If this is the case, we continue in the running state, but with the ARC condition true. This causes the software to apply a different set of criteria in converting the drive signal into a PWM duty cycle than it does during a normal (non-ARC) run.

3.1.4 COASTING

This state exists after we have entered the RUNNING state and have subsequently seen the RUN_IN signal become FALSE. In this state, the polling loop continues to run and monitor RUN_IN and Fault conditions. In this state we also monitor the COAST_IN signal. This state always exists between RUNNING and BRAKING states.

3.1.4.1 COAST_IN Detected

If COAST_IN is TRUE we remain in the COASTING state.

3.1.4.2 COAST_IN Not Detected

If COAST_IN is not TRUE, we enter the BRAKING state.

3.1.4.3 RUN_IN Detected

This commands firmware to recommence application of forward torque to shaft. SRDRIVE is used to calculate PWM output; RUN_OUT, and FORWARD are asserted to the drive box and the PIC program moves back to the RUNNING state.

3.1.4.4 Fault Detected

When a Fault condition is detected in the COASTING state, we leave the RUN_OUT signal to the drive box in the coast state (negated), propagate the Fault condition to the control system and enter the TERMINATE state. We will not escape the TERMINATE state without a control system reset.

3.1.5 BRAKING

In this state, we monitor rotational speed, rotational direction, RUN_IN, and FAULT signals. We negate the FORWARD signal (apply reverse torque) to the drive box and calculate a braking PWM signal based on rotational speed.

3.1.5.1 RUN_IN Detected

This commands firmware to recommence application of forward torque to shaft. RUN_OUT is negated to the drive box and the PIC program moves back to the COASTING state.

3.1.5.2 Fault Detected

When a Fault condition is detected in the BRAKING state, we set the RUN_OUT signal to the drive box in the coast state (negated) enter the TERMINATE state. We will not escape the TERMINATE state without a control system reset.

3.1.5.3 Speed Above 100 RPM

In this condition we continually calculate a braking PWM signal based on rotational speed and apply this signal to the drive box interface.

3.1.5.4 Speed Below 100 RPM

In this condition, we are close enough to 0 that we do not want to risk going into reverse through continued application of reverse torque. We transition to the COASTDOWN state.

3.1.5.5 Reverse Rotation Detected

In this condition, we negate the RUN_OUT signal (coast) and enter the COASTDOWN state. We are assuming that this is merely a transitory condition not involving significant (safety threatening) rotor speed.

3.2 Program Structure

The operating program is composed of an initialization group, a cyclical control loop, and a set of interrupt service routines. The functions performed depend on input pins, counters, an analog to digital converter, a PWM generator, and output pins. Before we can describe initialization, we have to describe the function assigned to each hardware resource.

3.2.1 Drive PIC Pins

Table 1 Shows the functions assigned to each pin on the Drive PIC part. This is the basis for configuration of the I/O ports.

PIC Pin Name	#	Type	Functional Signal Name	Description
!MCLR/VPP	2			Used by Debugger
RA0/AN0	3	Analog Input	SRDRIVE	Analog Control Voltage for Drive Torque
RA1/AN1	4	Digital Input	SLOW_RY	Coast signal from control system
RA2/AN2	5	Analog Input		Negative side of external reference voltage
RA3/AN3	6	Analog Input		Positive side of external reference voltage
RA5/AN4	8	Digital Input	RUN_RY	High True Command from Control System to Provide Forward Drive Torque
RE0/AN5	9	Digital Input	WDI1	Watchdog Input from Safety PIC
RE2/AN7	11	Digital Output	IIC_BUS_SEL	High selects IIC bus to NV Memory on Motor
RCO	16	Digital Output	DBOX_FAULT#	Low True Fault indication from drive box

				(filtered by software)
RC1/CCP2	18	Digital Output	PWM	PWM Output to Drive Box (PWM frequency set by software)
RC2/CCP1	19	Digital Input	S5	Hall Effect Sensor Output from Motor (Primary Tach)
RC3/SCL	20	Digital Output	SCL	Serial Clock Output for IIC Bus
RD0	21	Digital Output	MOT_COOL_EXTEND#	Low True Signal to Drive Motor Cooling Fan On
RD1	22	Digital Input	MOT_COOL_CALL#	Low True Input Indicating call for Motor Cooling from Main Control
RD2	23	Digital Input	MOTOR_OVERTEMP	High True Indication From Drive Box that a Motor Over-temperature Condition Exists
RD3	24	Digital Output	Not Used	Not Used
RC4/SDA	25	Digital I/O	SDA	Serial Data I/O for IIC Bus
RC5	26	Digital Input	FAULT#	Raw Low True Fault Indication from drive box
RD4	30	Digital Output	DYNAMIC_BRAKE	Low True Output Command to Drive Box (not employed by this design)
RD5	31	Digital Output	RUN	High Value Commands Drive Box to Supply Torque to Motor
RD6	32	Digital Output	DIRECTION	High Value Commands Drive Box to Apply Torque in Forward Direction; Low Reverse
RD7	33	Digital Output	DRIVE_ENABLE	Falling Edge Resets Drive Box; Rising Edge Starts Re-initialization (3 seconds required)
RB3/PGM	39			Used by debugger (Programming Enable)
RB4	41	Digital Input	S4	Hall Effect Sensor Output from Motor Interrupt-on-change input for direction detection
RB5	42	Digital Output	WDO2	Watchdog Output to Safety PIC
RB6/PGC	43			Used by debugger (Programming Clock)
RB7/PGD	44			Used by debugger (Programming Data)

Table 1 PIC Pin Function Assignments

3.2.2 A/D Converter

The A/D converter is used to digitize the SRDRIVE control voltage. The full-scale value (i.e. input voltage that will digitize as all 1s) is set by the external reference voltage on pins AN2 and AN3 (2.5 volts). We are using Analog Channel 0 (AN0) for our input. Because our operating frequency FOSC is 20MHz we must set our conversion clock no faster than FOSC/32 to guarantee the minimum bit conversion time is met. Using FOSC/64 gives a margin for error if the oscillator speed deviates above the nominal value.

3.2.3 PWM Module

We are using the CCP2 module for generating the PWM output. The period is a value that is fixed at initialization time by setting the Timer2 prescale value to 4 and the PR2 value to 0xFF. This gives 4.88KHz as a PWM frequency with 10 bits of resolution. The duty cycle is continually updated in response to the detected value of SRDRIVE.

3.2.4 Capture Module, Timer1, and Tach Signal

CCP1 module is used to capture the value of the free-running 16-bit Timer1. The timer runs on a time base established by our processor clock (20MHz). This clock is divided by 4 before it is presented to the prescaler input, so we are starting with a 5MHz clock. The tach signal provides a positive transition twice per revolution. We configure the capture to occur on every transition (our choices are limited to 1, 4, or 16). Even using the prescaler to divide the clock by 8 (which we do), the timer will increment at a rate of 5*10^6/8=625000 times per second. At 10rpm (1/6Hz) we have 3 seconds between captures or 625000*3 counts. This overflows the 16-bit timer (65536) many (>28) times, so we must configure the timer to interrupt on overflow so we can count the number of overflows to calculate ticks in a half revolution. At 21000rpm we get (21000/60)*2 = 700 captures/second. This gives 625000/700=892 ticks/capture (and no timer overflow interrupts).

We have three uses for the tachometer speed information.

1. To determine if we are in the controlled acceleration/deceleration range: These speeds are 512rpm and 768rpm. We have good speed resolution available at these clock speeds (roughly +-50RPM).
2. To determine when we are approaching 50rpm where we switch to coasting: Here again we have very good resolution.
3. For calculating the maximum allowed amount of applied torque for braking.

On the constant horsepower section of our drive curve (at speeds higher than 7100rpm) we apply the following calculations. T_{MAX} = 1.7HP/Speed. This value is going to range from 15inch-pounds at the boundary (7100rpm) down to 5.1 inch-pounds at the highest possible speed (21000rpm). Since our PWM resolution is limited to ~1/854 worst case to cover the range of 0 to 15 inch-pounds (1/1023 best case), we only have ~563 discrete values of PWM to apply in our operating range.

((15-5.1)/15)*750 = 563

((15-5.1)/15)*1023 = 675

Dividing the range of 7100-21000 by 563 gives us roughly 25rpm resolution. Dividing by 675 gives approximately 21 rpm resolution. Since we cannot resolve our drive current for any interval finer than 21rpm, prescaling the timer by 8 is a reasonable compromise to avoid excessive work in servicing timer overflows at the lower speeds. Below 7100 rpm, we simply limit the maximum applied PWM signal to one that will give us 14inch-pounds opposed to rotation. Our resolution of speed is also limited by the variability of the time between positive transitions from the Hall Effect sensors. We have observed jitter of more than 5%. Therefore, it does not make sense to assume we are getting a very accurate measurement of speed. The consequence of these cumulative effects is that we must be conservative in our calculation of maximum torque that can be applied at any point where maximum permitted torque is speed-related. We accomplish this in the code by using a slightly steeper downward curve and starting the slope at a slightly lower speed.

3.3 Program Functions

3.3.1 Direction Detection

This function is based on an interrupt service routine triggered by a transition on PIC pin RB4. This ISR reads pins RC2 and RB4. If these pins have the same value, the global value REVERSE is set to FALSE. Otherwise, the value of REVERSE is set to TRUE.

3.3.2 Changing Direction of Applied Torque

When the system is commanded to a braking mode, there is a transition from torque assisting rotation to torque opposed to rotation. This is accomplished by performing the following steps in order:

1. Remove RUN signal from drive box interface (coast).
2. Set output value of PWM to zero.
3. Delay (3ms)
4. Change DIRECTION signal to new direction.
5. Delay (3ms)
6. Measure speed and calculate proper torque (PWM).
7. Apply PWM.
8. Delay (.5ms)
9. Assert RUN signal.

3.3.3 Extended Run Time for Motor Cooling Fan

Approximately once per second, the PIC firmware reads input pin RB1. If the value on this pin is low, the output pin RB0 is driven low. At all other times (including initialization time) output pin RB0 is driven high.

3.3.4 Speed Detection

Background to this subject is detailed in 3.2.4. Any time that the interrupt for a Timer1 overflow occurs, we increment an 8-bit counter. When the CCP1 module captures the timer value after a positive transition on pin CCP1 we:

1. Store the current tick counter computed in the previous iteration of step 2 in a temporary variable.

2. Add the captured timer value to our overflow count multiplied by 2^16.
3. Subtract the value in the temporary variable from the value computed in step 2.

The difference of the current value and the previous value of the extended timer is the number of ticks that have happened in one-half of a revolution. Then we have the relationship Speed(rpm) = 60*(312500/delta-ticks). This number is based on a 5MHZ clock being divided by a 8 prescale value and recognizing that we have counted for one half of a revolution.

3.3.5 Coast Down

When the RUN_RY pin (PIC pin RA2) registers FALSE and the SLOW_RY pin (PIC pin RA1) registers true, we know that we need to place the motor in coast mode. We do this by asserting a 0 on the RUN signal to the drive box (put 0 on PIC output pin RD5).

3.3.6 Motor K_e detection

There is an I2C memory associated with each drive motor. This memory holds the maximum PWM duty cycle (on a scale of 0 to 1023) allowed based on the K_e value for this motor. The PIC firmware reads this value over the I2C bus and stores it in a readily-accessible memory location for use in computing required PWM output. This value is specifically referred to as PWM_{MAX}. We use it to determine the sensitivity of the motor to changes in applied current and hence changes in applied PWM. This is explained in detail under 2.1.6.4 PWM. The value is obtained by reading 2 bytes starting at memory address 0 in the I2C device located at I2C device address 0xA9. The first byte is the MSB of the PWM number and the second byte the LSB.

3.3.7 Braking

Braking is accomplished by torque opposed to rotation. Applied torque must not exceed 15 inch pounds. The maximum horsepower available from our motor is 1.7. The boundary between constant horsepower and constant torque occurs at 7100rpm (118Hz or 743.5 radian/sec). Maximum applied braking torque is inversely proportional to rotational speed when in the constant-horsepower operating region. This means that maximum applied torque is inversely proportional to rotational speed according to the equation:

$$T_{MAX} = HP/Speed$$

To get our units right, we'll use inch-lbs/second for power and radians/sec for rotational velocity. The numbers are calculated as follows: 1hp = 550.221342 foot-lbs/sec = 6602.656104in-lbs/sec. So Torque = (1.7 * 6602.656104)/Speed (radians/second). We'll assume 7 digits of precision for our horsepower rating and use the number T_{MAX} = 11224.52/rotational velocity. For example, given we are braking at a speed of 17000rpm (1780.234 radians/sec), we have T_{MAX} = 11224.52/1780.234 = 6.31 in-lbs.

When on the constant torque portion of the curve, a constant 14 inch-pounds of torque may be applied. Braking torque is also conditional upon direction of rotation. If forward rotation is detected, torque opposed to rotation can be applied. If backward rotation is detected, no backward torque can be applied.

3.3.7.1 Braking Algorithm

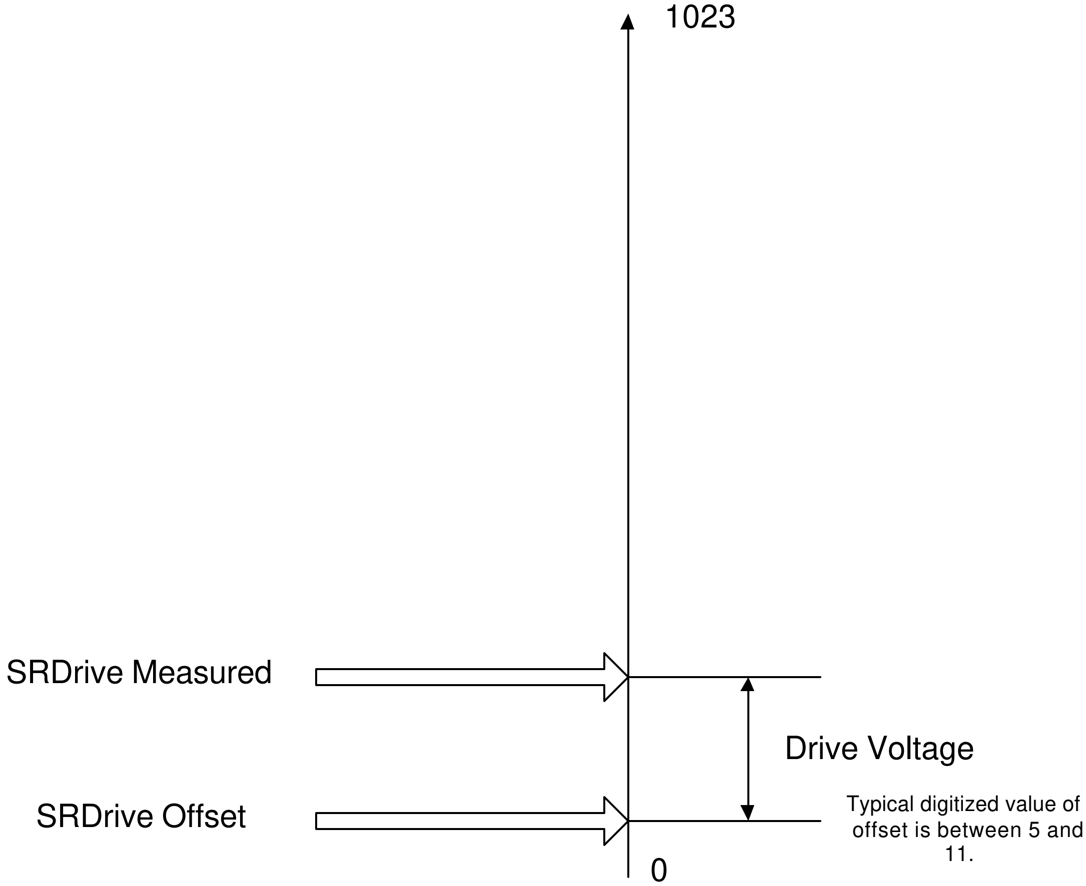
Because we require that the braking speed profile be as smooth as practicable without prior knowledge of the mass of the rotor to be slowed, we have designed an algorithm to capture speed, compute torque, and apply the computed torque. We must also anticipate when the braking torque may carry us past 0 velocity and cause reverse rotation or cause us to brake when we should be coasting or decelerating in a controlled fashion (i.e. ARC active).

With the lightest rotors, deceleration occurs so fast that we have to stop providing reverse torque at 100 RPM so that we do not drive the rotor into reverse. Given a constant reverse torque of 14 inch-pounds, we drive rotors with less inertia than the SS-34 into reverse even when we stop applying torque at 100 RPM. For this reason, we start to taper off the braking torque slowly at 2000 RPM and more rapidly at 500 RPM.

3.3.7.2 Controlled Deceleration (ARC)

When the ARC mode of operation is selected, the centrifuge is in the deceleration mode of operation, and the rotor speed falls below 768RPM, the control algorithm requires that the remainder of the deceleration to 0RPM occur at a programmed rate. Normally, what we observe is that the system reasserts the RUN signal and provides a level of SRDRIVE sufficient to accelerate the rotor back above 768RPM and then a reduced level low enough to permit wind drag and friction to decelerate the rotor to 0 according to a program specific to that rotor. This contrasts to the approach used with the brush RC-5C where actual braking torque could be used to make braking happen a little faster than coasting in ARC mode. In the present implementation we will see an increase in deceleration time that is more pronounced with higher inertia rotors. The mechanism by which required torque is computed is explained in 3.3.9.

There is one additional consideration posed for ARC stop because of the possible presence of noise on the SRDRIVE signal. Because the SRDRIVE signal is so small relative to system noise (Meaningful levels of less than 30mV are typical during ARC stop while noise levels can vary about this level by as much as 150mVAC) we can effectively rectify system noise (since we measure values below 0 as 0) and treat it as an actual drive signal. The symptom of this condition (frequently seen at high ambient temperatures) is that the rotor will decelerate to below 768RPM, then slowly accelerate back to above 800RPM and stay there indefinitely. We have introduced a safety net type fix for this condition by subtracting an additional offset from the commanded drive current when we see that the rotor has accelerated above 800RPM during an ARC stop.



3.3.8 Normal Acceleration

For this condition we apply torque in the forward direction in proportion to the detected level of SRDRIVE and the computed maximum torque value. The signal RUN_RY is active.

3.3.9 ARC Acceleration

For this condition we apply torque in the forward direction in proportion to the detected level of SRDRIVE. The maximum permitted torque value is always 100% of that available when we are in the ARC region (0-512 RPM) so we just use SRDRIVE and apply some computations (SRDRIVE/4) to match the acceleration profile to that observed on the original RC-5C+ in ARC mode acceleration.

Figure 3 SRDRIVE used in ARC Mode

There are two important things to note about the SRDRIVE signal. First is that the signal is never actually 0. Therefore, we have to subtract a baseline offset from SRDRIVE before we attempt to decide what the control system is commanding. Otherwise we would conclude that the system was always commanding some forward torque. The second point to remember is that the resolution of the SRDRIVE signal from the control system is about 5mV while our ability to resolve is about 2.4mV. This means that our least significant digit does not reflect an actual change in the drive voltage. Experimentation leads us to choose an offset of 16 for the acceleration signal and 8 for the signal when we are in an ARC stop. An additional offset of 12 is applied during ARC stop when the noisy condition described in 3.3.7.2 is detected.

3.3.10 SRDRIVE Level Detection

SRDRIVE is an analog signal derived from a digital value in the main control microprocessor's program. It varies quasi-continuously between 0 and 2.5VDC. We detect this value and convert it to a digital value on the range of 0 to 1023 (10-bits) at a rate greater than 4.88kHz (PWM frequency).

3.3.11 PWM Computation

Numbers for the calculations are as described above in the paragraph on PWM. We simply multiply (10bit x 10bit -> 20bit) the computed value of PWM_{MAX} by the digitized value of SRDRIVE and shift the result right by 10 bits. The PIC program performs these calculations at the frequency described in paragraph 3.3.9 using the detected level of SRDRIVE. PWM duty cycle is updated after each calculation.

3.3.12 Drive Box Fault Detection

The FAULT# signal from the drive box is monitored by the polling loop when the RUN signal to the drive box is true (i.e. torque is being applied). If it is found to be asserted (Low True) for more than 100ms, a hard fault is declared and the control loop is aborted.

3.3.13 Motor Overtemp Detection

The I2C temperature sensor signal is monitored by the polling loop. If it is found to exceed the rated operating temperature for four consecutive polls, a hard fault is declared and the control loop is aborted. Access to the temperature sensor is shared by the safety and drive PICs. Both PICs use the same function to access the sensor and take alternate turns reading the sensor. If either PIC detects a problem in reading the sensor (not a legitimate overtemperature reading) it skips its next access turn. The skipped next turn is interpreted as a fault also but the sensor actually is given an additional period of time in which it is not accessed. If the subsequent read of the processor returns an access error, a declared fault is guaranteed after the next access turn. If a legitimate overtemperature is read 4 times in a row, a fault is declared by whichever PIC reads the excessive temperature first. The net effect of this approach is that when either PIC detects two consecutive errors in reading the sensor or four consecutive temperature readings over 120C, it declares a fault and terminates operation of the motor.

4 PWM Monitor PIC Firmware Design

This section describes the program for the PWM Monitor PIC microcontroller and how it performs its role of guaranteeing that we do not exceed safe torque limits. First, we describe the sequence of monitoring and control performed by the program. Second, we describe the top-level design in terms of the task and interrupt structure. Next we describe the actions required for each possible set of operating conditions. Finally, we place the actions in the context of the operating software (i.e. Describe each ISR and polling operation and the data structures upon which they act.).

4.1 Operational Sequence

This section describes each possible set of operational events for every possible operational state. This control program is much simpler than that of the drive PIC; it is just a continuous control loop that monitors speed, PWM duty cycle, and responsiveness of the drive PIC control program. The liveness protocol state machine is used on this PIC and works exactly as it does on the drive PIC.

Note: When a Fault condition is detected, the enable signal is immediately set to 0 and the control loop is aborted. The fault signal may also be propagated to the main control system for certain fault types. The processing of that signal is outside the scope of this document.

4.1.1 Initialization Stub

This part of the program reads the motor Ke and calculates the maximum PWM duty cycle permitted on the constant torque portions of the curve. From this information we later derive the maximum duty cycle for any given speed on the constant horsepower curve.

4.1.2 Control Loop

This structure is repeated after initialization and as long as no hard fault is detected.

4.2 Program Hardware Resources

Here we describe the function assigned to each hardware resource.

4.2.1.1 Fault Detect Indications

The Safety PIC controls two LED indicators which it uses to show the user when it detects a fault. When the drive interface board in mounted in a system, these LEDs are located in the lowest and third from lowest positions on the LED bar containing the various indicator LEDs. The lowest LED is designated A5 and the third from the bottom is designated A4. The following table shows the meaning of various combinations of these LEDs:

A4	A5	Condition	Possible Cause
Off	Off	No Fault	N/A
Off	On	Timeout Seizing	Drive PIC Detected Fault in Tach or Overtemp
On	Off	Drive Box Fault	N/A (Not Monitored)
On	On	Tachometer Disagree	Cabling or Motor Commutation Board Failure
Flash	Off	Motor Overtemp	Cabling failure or Motor Overtemp
Off	Flash	Timeout Releasing	Drive Interface Board
Flash	On	Not Defined	N/A
On	Flash	Duty Cycle Violation	Failure on Drive PIC (Drive Interface Board)
Synchronized Flash	Synchronized Flash	PWM Signal Pegged High	Failure on Drive Interface Board
Alternating Flash	Alternating Flash	Error in Ke Memory	Cabling or Motor Ke Memory Failure
Alternating Flash on for one second	Alternating Flash on for one half second	Bad Message from Drive PIC	Drive Interface Board

4.2.2 PWM Monitor PIC Pins

Table 1 Shows the functions assigned to each pin on the PWM Monitor PIC part. This is the basis for configuration of the I/O ports.

PIC Pin Name	#	Type	Functional Signal Name	Description
!MCLR/VPP	1			
RA0/AN0	2	Digital Input	DBFAULT	Fault Signal from Drive Box
RA1/AN1	3	Digital Input	RUN_B	Run Signal from Drive PIC
RA2/AN2	4	Digital Input	WD011	Watchdog Handshake Line from Drive PIC
RA3/AN3	5	Digital Input	ILIMB	Not Used
RA4/TOCK1	6	Digital Input	FLTLED1	Fault Indicator
RA5/AN4	7	Digital Input	FLTLED2	Fault Indicator
RCO	11	Digital Input	DIRIN	Direction From Drive PIC
RC1/CCP2	12	Digital Input	PWMIN1	PWM Input from Drive PIC

RC2/CCP1	13	Digital Input	PWMIN2	PWM Input from Drive PIC
RC3/SCL	14	Digital I/O	SCL	Serial Clock Output for IIC Bus
RC4/SDA	15	Digital I/O	SDA	Serial Data I/O for IIC Bus
RC5	16	Digital Output	WD02	Watchdog Handshake Line to Drive PIC
RC6	17	Digital Output	DBOX_GATE	Enable Output for Drive Box Control
RC7	18	Digital Input	TSTIN1	Test Input
RB0	21	Digital Input	N/A	Not Used
RB1	22	Digital Input	N/A	Not Used
RB2	23	Digital Input	N/A	Not Used
RB3	24	Digital Input	N/A	Not Used
RB4	25	Digital Input	N/A	Not Used
RB5	26	Digital Input	DBTACH	Tachometer Signal from Drive Box
RB6/PGC	27	Digital Input	N/A	Not Used
RB7/PGD	28	Digital Input	N/A	Not Used

Table 2 PIC Pin Function Assignments.

4.2.3 PWM Monitor Module

We are using the CCP1 and CCP2 modules for monitoring the PWM output. CCP1 is set to capture the free running timer on the positive transition of the PWM signal and CC2 captures on the negative transition. The difference between these two numbers (CCP1 is captured first and read when CCP2 interrupt is serviced) is the amount of time the signal spent high. Since we know the frequency to be 4.88kHz, we compute duty cycle as a fraction of the number of ticks that will occur in 1/4880s.

4.2.4 Tach Signal

The tachometer on the safety PIC is based on the number of transitions on the tachometer signal in one second. The signal comes from the drive box and is the composite of the commutation sensor signals. Every transition (positive and negative) is counted by an interrupt service routine and the difference between successive values of this running count is computed by an interrupt service routine running off of a one-second timer.

4.3 Program Functions

4.3.1 Computation of Permitted Torque

The safety PIC uses the measured speed to compute the maximum permitted duty cycle as a proxy for torque at any given time during operation. The method of computation is the same as is used on the drive PIC and uses a common set of definitions in making the computation.

4.3.2 Detection of Excessive Torque

The safety PIC compares the duty cycle measured by the PWM monitor function to the computed maximum duty cycle by measuring the exponential average of the sample difference of measured and permitted maximum duty cycles. If measured exceeds permitted, the delta is the new error term, otherwise 0 is the new error term. The new error term is summed to the previous error term and the new error term is obtained by dividing the result by 2. When this average exceeds the duty cycle delta corresponding to ½ inch-pound, an error is declared and operation of the drive box terminated.

4.3.3 Detection of Stuck PWM Signal

The safety PIC uses the interrupt service routines for the CCP1 and CCP2 events to detect whether the PWM signal has remained high for an unacceptable length of time. It does this by defining two variable flags: risingEdge and fallingEdge which are initialized to FALSE. At initialization time, the pin that monitors the CCP events is read and if it is high risingEdge is set to TRUE, otherwise falling edge is set to TRUE. Any time that the CCP1 event occurs (rising edge on PWM pin), the flag risingEdge is set to TRUE. Any time that the CCP2 event occurs (falling edge on PWM pin), the flag fallingEdge is set to TRUE. In the main control loop, any time that the risingEdge flag is seen to be TRUE, the program sets both risingEdge and fallingEdge to FALSE. One half of a second after this event, the program tests fallingEdge. If fallingEdge is still FALSE, our rotational speed is above a defined threshold, and we detect that the drive box run signal is TRUE; a fault is declared and operation is terminated.

4.3.4 Torque Direction Detection

The safety PIC does not detect direction of rotation. It can sense the direction of applied torque by monitoring the DIRECTION pin to the drive box. It also receives a message once per second from the drive PIC indicating the direction in which the drive PIC is applying torque. If these two data disagree, a fault is declared and enable to the drive box in interrupted.

4.3.5 Motor K_e detection

This operating parameter is read from a memory module associated with the motor in exactly the same way as is done by the drive PIC.

4.3.6 Drive Box Fault Detection

The FAULT# signal from the drive box is not monitored by the safety PIC.

4.3.7 Motor Overtemp Detection

The I2C temperature sensor signal is monitored and handled by the polling loop in exactly the same manner as on the drive PIC.

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Table of Contents

5.0 Troubleshooting

Section 10. TROUBLESHOOTING

10-1. SYSTEM DIAGNOSTICS AVAILABLE

Diagnostics are available for troubleshooting during normal and zonal runs and for system analysis in the NORM (NORMAL) and DIAG (DIAGNOSTIC) modes.

a. Normal and Zonal Run Diagnostics

The diagnostic indicators numbered 1 through 16 on the front control panel, Figure 2-1, are used to indicate operation conditions or problems during normal or zonal runs (at this time, only numbers 1-12 are used).

Each numbered diagnostic indicator is listed below with its description and corrective action.

1) CONTROL SYSTEM FAILURE. Press the START switch to restart the run. If the light comes on again, check the brushes, the Microcomputer Board, and for intermittent connections. Noise from the motor or compressor, or on the ac line can cause this failure.

2) PROGRAM FAILURE. Fatal checksum error. Light goes on and stays on, there is no display. ROM chips or Microcomputer Board failure gives checksum error. Replace Microcomputer Board.

3) MEMORY SYSTEM FAILURE. Fatal error. Light goes on and stays on, there is no display. RAM chips on Microcomputer Board fail. Replace Microcomputer Board.

4) DRIVE SYSTEM FAILURE. No speed indication, no power to motor. Check the tachometer, run and slow start relays, and the analog control signal on the High Voltage Interface Board.

5) OVERCURRENT. The motor exceeded the preset current limit. Press the START switch to restart the run. If the light comes on again, check current limit calibration (High Voltage Interface Board), check for tight bearings or a bad motor.

6) NO ROTOR. The microcomputer detected a sudden and sustained increase in rpm; no rotor was installed when START switch was pressed. The centrifuge runs for a few seconds and then shuts off. Install a rotor and restart the run. If the rotor is installed and light comes on again, check for a broken or loose coupling, or carbon dust on the tachometer.

7) REFRIGERATION SYSTEM FAILURE. There was no apparent drop in chamber temperature thirty seconds after the refrigeration system started to cool or floor temperature sensor detects temperature above 50°C. Run in progress is terminated. Check that the refrigeration system, control for the compressor, and the compressor itself function.

8) TEMPERATURE SENSOR FAILURE. Chamber air temperature sensor failure. Replace the sensor.

9) TEMPERATURE SENSOR FAILURE. Chamber floor temperature sensor failure. Replace the sensor.

10) COMPUTER SYSTEM FAILURE. The computer received erroneous information. The condition clears and the light goes out if the problem is momentary. If the condition persists, check for a source of high electrical noise, intermittent connections, or a faulty Microcomputer Board. Change the Microcomputer Board.

11) TACHOMETER ERROR. The computer detected changes in rpm beyond the normal range, indicating that the tachometer input frequency is unstable. The condition clears and the light goes out if the problem is momentary. If the condition persists, check that the tachometer interrupter disc is centered and that no teeth are broken off or bent. Check for intermittent connections. Verify that there is no dust or debris on the photo coupled interrupter.

12) REGISTER OVERFLOW. The condition clears and the light goes out if the problem is momentary. An incorrect entry on one of the control switches can cause this light to come on. If the ENTRY ERROR light is on, check all control settings. If all settings are correct, and the condition persists, check for a defective Switches and Indicators Board.

13) NOT USED.

14) NOT USED.

15) NOT USED.

16) NOT USED.

b. System Analysis Diagnostics

The diagnostics used for system analysis in the NORM and DIAG modes fall into four groups: watch-dog, start-up, dynamic, and static.

1) WATCH-DOG: there is a hardware one-shot circuit which must be refreshed at least every 120 msec., and this is done by the program at 100 msec. intervals. If normal program flow is interrupted, the watch-dog will time out. The time out disables the drive, terminates the run, and lights diagnostic indicator #1.

2) START-UP DIAGNOSTICS

a) RAM Test: verifies that all 2048 bits of the system read/write memory can be set and cleared. This test will not terminate until it is successful. Diagnostic indicator #3 is turned on at the beginning of the test and turned off after the successful completion of the test.

b) ROM Test: verifies the proper contents of the system ROM's. A check-sum is calculated, and the test will terminate only if the check-sum calculated during the test equals the predetermined check-sum value. Diagnostic indicator #2 is turned on at the beginning of the test and turned off after the successful completion of the test.

c) Display Test: allows the user to determine if all console displays are functioning properly. This test will execute only if the rotor code lever switches are set to 00 when the system is powered up or reset. This test lights all the console displays and indicators except the RCF indicator. After about 5 seconds, the displays turn off in sets at one second intervals.

3) DYNAMIC DIAGNOSTICS

These diagnostics are activated when either S2 DIAG/NORM switch is set to DIAG; or when the jumper plug is installed on J58 (indicating Diagnostics Mode) on the Microcomputer Board and the program is in normal operation.

a) TEMP Display Diagnostic: uses the temperature display to show temperature values other than sample temperature. The setting of the ones digit of the TIME MIN leverwheel switches selects the value to be shown, Table 10-1.

Table 10-1. Temperature Values

MINUTES SWITCHES	TEMPERATURE VALUE SHOWN
00	Air Temperature Sensor (+60°C to -40°C)
01	Floor Temperature Sensor (+60°C to -40°C)
02	Maximum Displayed Sample Temperature
03	Minimum Displayed Sample Temperature
04	Estimated Sample Temperature (Temperature Control Value)
05	Displayed Sample Temperature
06-09	Displayed Sample Temperature (Maximum and Minimum Temperatures Sent to Display)

b) SPEED Display Diagnostic: suppresses the forced trailing zeros of the SPEED display.

c) Pull Down Diagnostic: allows the compressor to run continuously in order to determine refrigeration performance. To force this condition, the rotor must be running at 20 000 rpm, the rotor code must be set to 05, and the run temperature must be set to 00.

d) Flags and I/O Display Diagnostic: displays system inputs (SYSINP), outputs (SYCTRL), flags, and variables as 8 bits of data on the diagnostic indicators 1 through 8. The 8 bits of data are read from the diagnostic indicators as follows:

Diagnostic Indicator Number	1	2	3	4	5	6	7	8
Bit Number (from MSB to LSB)	7	6	5	4	3	2	1	0

The data to be displayed is selected by the ten's digit of the TIME HRS leverwheel switches, Table 10-2.

Table 10-2. Flags, I/O, and Variables

HOURS SWITCHES	I/O, FLAG, OR VARIABLE TO BE DISPLAYED
00	SYSINP (System Input Port)
10	SYCTRL (System Control Outputs)
20	DSTATS (Diagnostic Indicator Flags)
30	TMPSTS (Temperature Status Flags)
40	STATS (System Status Flags)
50	CFAILT (Compressor Fault Timer)
60	SPDSTS (Speed Status Flags)
70	SYSMEM (Fault Memory)
80	DELTAS (Delta Speed Value, .1 Sec)
90	TDIV (Tach Divide Value)

e) Speed Control Parameters Diagnostics: aids in the selection of these parameters for future rotors. The low digit of the hours leverwheel switches (values 0, 1, 2 and 3) selects the speed control zone gain factor. The high digit of the minutes leverwheel switches (values 0, 1, 2, and 3) selects the speed control anticipation zone gain factor. If this feature is not being used, a default value of 3 is recommended for both parameters.

4) STATIC DIAGNOSTICS

These diagnostics are activated with the system in the stand-by state (not running). Either set the S2 DIAG/NORM switch to DIAG or install jumper plug to J58 (indicating Diagnostics MOde) on the Microcomputer Board and press the RCF switch. This causes all front panel displays to blank out except for the HOLD advisory message. One of six different diagnostic routines can be selected. The routine is activated by setting the tens's digit of the ROTOR CODE leverwheel switches to the requested diagnostic routine and pressing the START switch. Routines are deactivated by pressing the STOP switch.

Control can be passed back to the main control program by setting the S2 DIAG/NORM switch to NORM and stopping any diagnostic routine which may be executed by pressing the STOP switch. The six diagnostic routines are listed in Table 10-3 and the corresponding charts are Tables 10-6 through 10-11.

Table 10-3. Static Diagnostic Routines

ROTOR CODE SWITCHES	DIAGNOSTIC ROUTINE
00	Undefined
10	Lever Switch Test #1
20	Lever Switch Test #2
30	Display Test
40	A/D & D/A Test
50	Output Test
60	Input Test

a) Switch Test #1, Diagnostic Routine #10: the speed leverwheel switch settings are shown in the speed display. The TIME/$\int\omega^2 dt$ leverwheel switch settings are shown in the TIME/$\int\omega^2 dt$ display. Refer to Table 10-6.

b) Switch Test #2, Diagnostic Routine #20: the temperature leverwheel switch settings are shown in the TEMP display. The TEMP MAX (overtemp) leverwheel switch settings are shown in the high digits of the SPEED display. The ROTOR CODE leverwheel switch settings are shown in the MIN part of the TIME display. Refer to Table 10-7.

c) Display Test, Diagnostic Routine #30: the value of the one's digit of the ROTOR CODE leverwheel switch is shown on all the numeric displays, and the minus sign also lights for values of 2, 3, 4, 5, 6, 8, and 9. The advisory messages, OVERSPEED, OVER TEMP, DOOR, ROTOR CODE, ENTRY ERROR, BRUSHES, OUT OF BALANCE, FAULT, HOLD, and $\int\omega^2 dt$ also light for the values 0 through 9, respectively. The diagnostic indicators 1 through 8 light for values 0 through 7, and diagnostic indicators 11 and 12 will light for values of 8 and 9. Refer to Table 10-8.

d) A/D & D/A Test, Diagnostic Routine #40: the filtered A/D value is displayed on four digits of the SPEED display. Even values in the one's digit of the ROTOR CODE leverwheel switches multiplex the air temperature sensor, odd values select the floor temperature sensor. For values of 0 and 1, the display is offset by 4000, for a range of +60.00°C to -40.00°C (the minus sign is displayed as a lower case c). For all other values, the range is 0 to +0.9999 volts. The value of the speed leverwheel switches is output to the D/A converter. The switch range is 0 to 4100, for an output voltage range of +0 to +(TP7) volts. Any switch value above 4100 also causes an output voltage equal to that at TP7. Refer to Table 10-9.

e) Output Test, Diagnostic Routine #50: this routine activates one of five outputs for a specified number of seconds. The output is selected by the one's digit of the ROTOR CODE leverwheel switches, and the time (plus 1 second) is selected by the one's digit of the TIME HR leverwheel switches. The output number selected is shown on the one's digit of the TIME MIN display as long as the output is active, when not active or times out, the letter U is displayed. The count down (time +1) is displayed on the one's digit of the TIME HR display. The output activates when the start switch is pressed. It can be held on past the time out if the START switch is held down, or turned off before the time out by pressing the STOP switch. The five output values are listed in Table 10-4. Refer to Table 10-10.

Table 10-4. Output Activation

ROTOR CODE SWITCHES	OUTPUT ACTIVATED
50	Not Used
51	Brush Lift
52	Compressor Relay
53	Door Solenoid
54	Run Relay
55	Slow Relay
56-59	Not Used

f) Input Test, Diagnostic Routine #60: The input logic states (0 or 1) of 11 system inputs are shown from left to right on the numeric displays, Table 10-5. Refer to Table 10-11.

Table 10-5. System Inputs Logic State

NUMERIC DISPLAY POSITION	SYSTEM INPUT
TEMP	HOLD/OFF Switch
TEMP	$\int\omega^2dt$/OFF Switch
SPEED	CURRENT LIMIT
SPEED	ZONAL KEY Switch
SPEED	IMBALANCE
SPEED	WORN BRUSH
SPEED	RCF/RPM Switch
HOUR	FAULT MEMORY
HOUR	ARC/OFF Switch
MIN	DOOR CLOSED
MIN	BRAKE/OFF Switch

10-2. SYSTEM CHECK AND STATIC DIAGNOSTIC AND GENERAL TROUBLESHOOTING CHARTS

Before performing any of the static diagnostics, perform the following system check. Once the system checks out, perform the Static Diagnostics using Tables 10-6 through 10-11. Use Tables 10-12 through 10-21 for general troubleshooting.

a. System Check

- Verify that the system RAM and ROM memories function by performing the Start-Up Diagnostics, RAM test and ROM test.

- Verify the proper operation of the control panel displays by performing the Start-Up Diagnostic, display test.

- Check each of the 4 power supplies of the system. CB102 protects PSI (+5, ± 12), CB101 protects T106 (+24, +160), T106 has an internal thermal fuse in the primary winding.

- Check for the presence of +5 Vdc: CR11 on the Microcomputer Board must be lit. Verify voltage at TP13 with respect to GND (TP14).

- Check for the presence of +12 Vdc: CR12 on the Microcomputer Board must be lit. Verify voltage at TP3 with respect to GND (TP14).

- Check for the presence of -12 Vdc: CR13 on the Microcomputer Board must be lit. Verify voltage at TP2 with respect to GND (TP14).

- Check for the presence of +24 Vdc (+4V, -1V): DS10 on the High Voltage Interface Board must be lit. Verify voltage at TP6 with respect to GND (TP5).

b. Static Diagnostics and General Troubleshooting Charts

Following are the static diagnostic charts, Tables 10-6 through 10-11; and the general troubleshooting charts, Tables 10-12 through 10-21.

NOTE

When a corrective action (item numbered in process block) is performed, the system must be retested to pass or fail the action before any subsequently numbered corrective actions are performed.

In the troubleshooting charts the High Voltage Interface Board is referred to as the HVI Board.

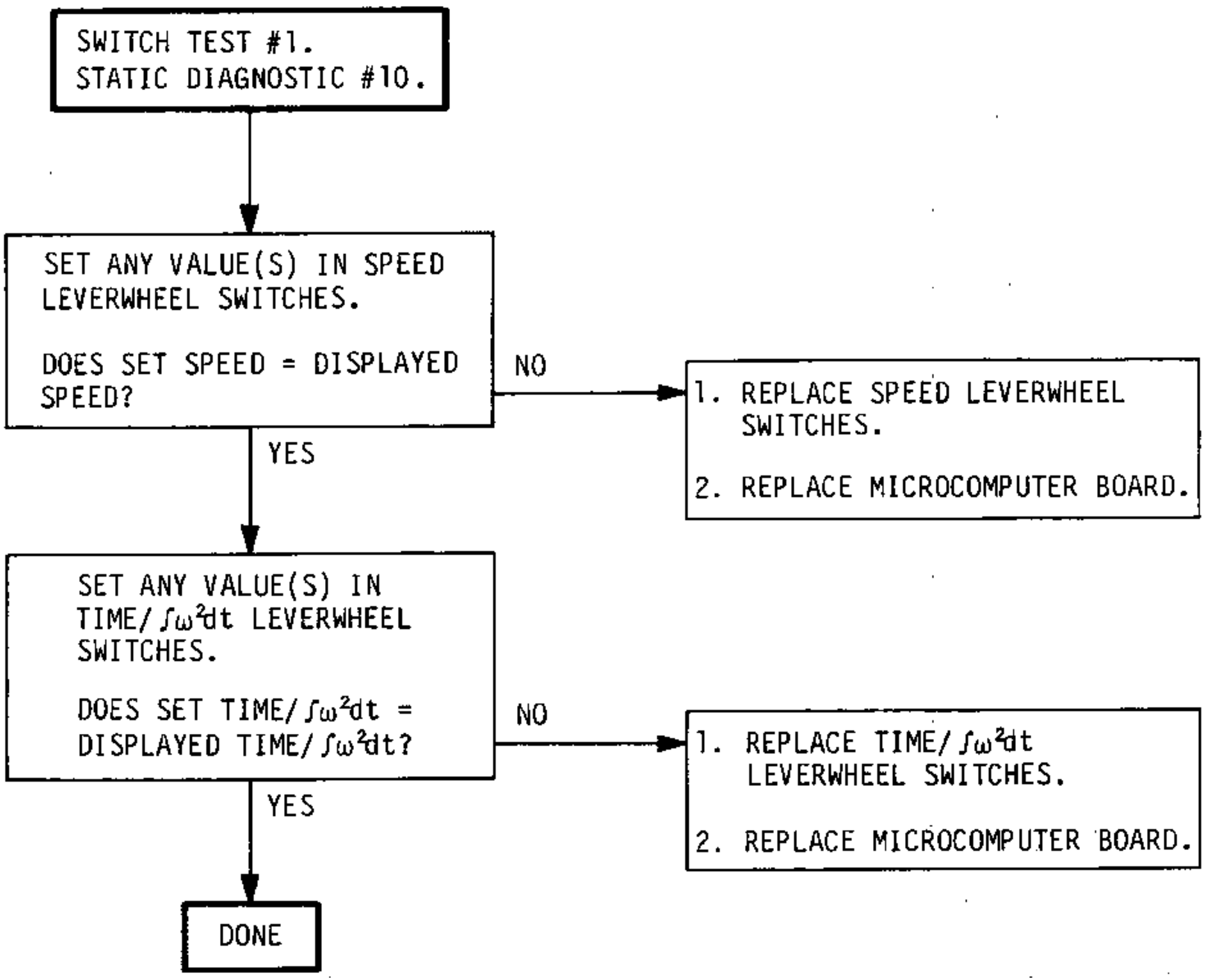


Table 10-6. Switch Test #1, Static Diagnostic #10

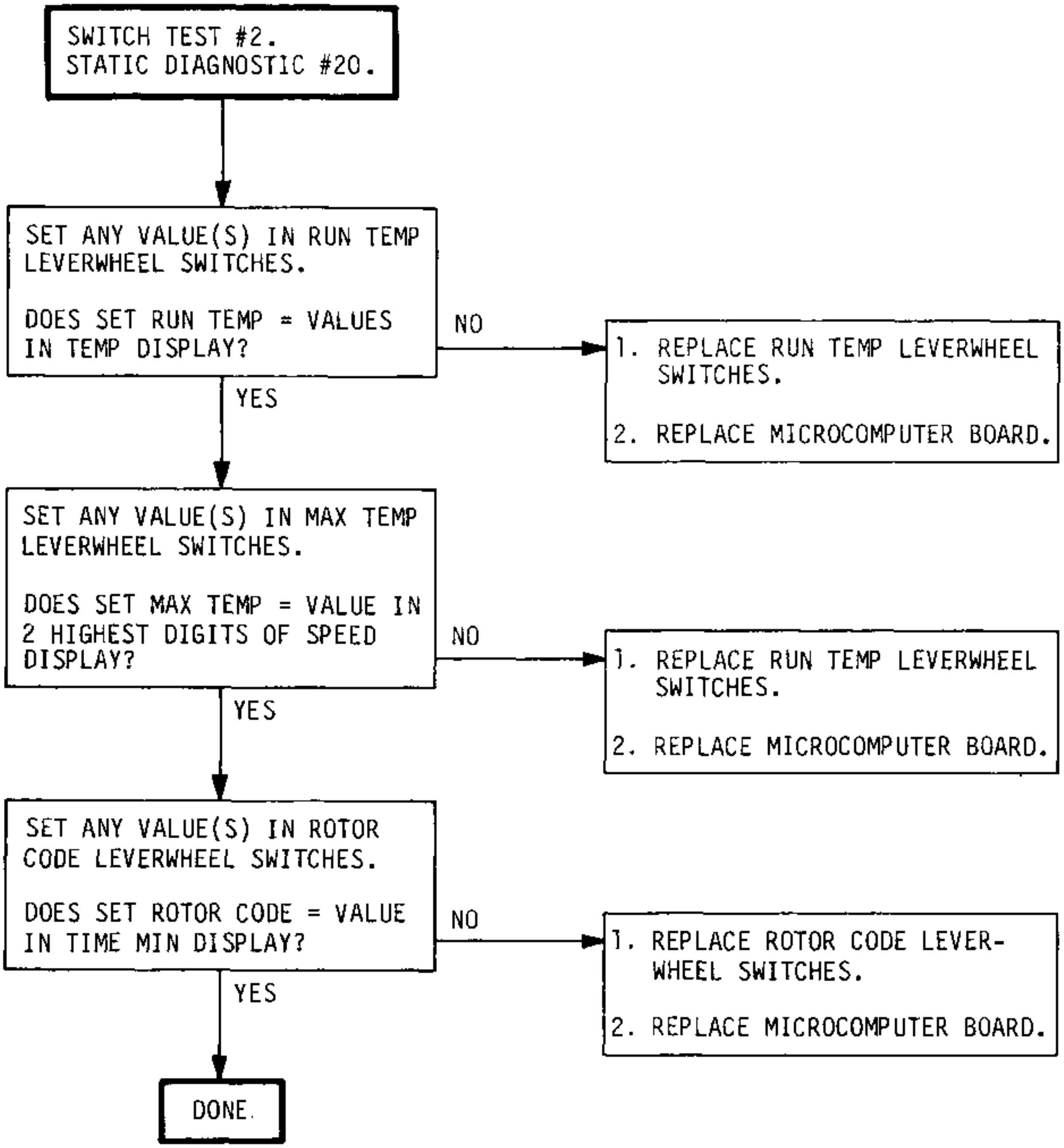


Table 10-7. Switch Test #2, Static Diagnostic #20

DISPLAY TEST.
STATIC DIAGNOSTIC #30.

Set the ROTOR CODE leverwheel switches to the following values and check the Indicated Displays, Diagnostic Indicators, and Advisory Messages.

ROTOR CODE	SIGN	VALUE IN DISPLAYS	DIAGNOSTIC INDICATOR	ADVISORY MESSAGE
30	NO SIGN	0	1	OVER SPEED
31	NO SIGN	1	2	OVER TEMP
32	-	2	3	DOOR
33	-	3	4	BRUSHES
34	-	4	5	OUT OF BALANCE
35	-	5	6	FAULT
36	-	6	7	ENTRY ERROR
37	NO SIGN	7	8	ROTOR CODE
38	-	8	11	HOLD
39	-	9	12	$\int \omega^2 dt$

INDICATED SIGN, DISPLAY, AND DIAGNOSTIC INDICATOR LIT?

NO

1. REPLACE LED DISPLAY BOARD.
2. REPLACE MICROCOMPUTER BOARD.

YES

INDICATED ADVISORY MESSAGE LIT?

NO

1. REPLACE LIGHT BULB.
2. REPLACE SWITCHES AND INDICATORS BOARD.
3. REPLACE MICROCOMPUTER BOARD.

YES

DONE

Table 10-8. Display Test, Static Diagnostic #30

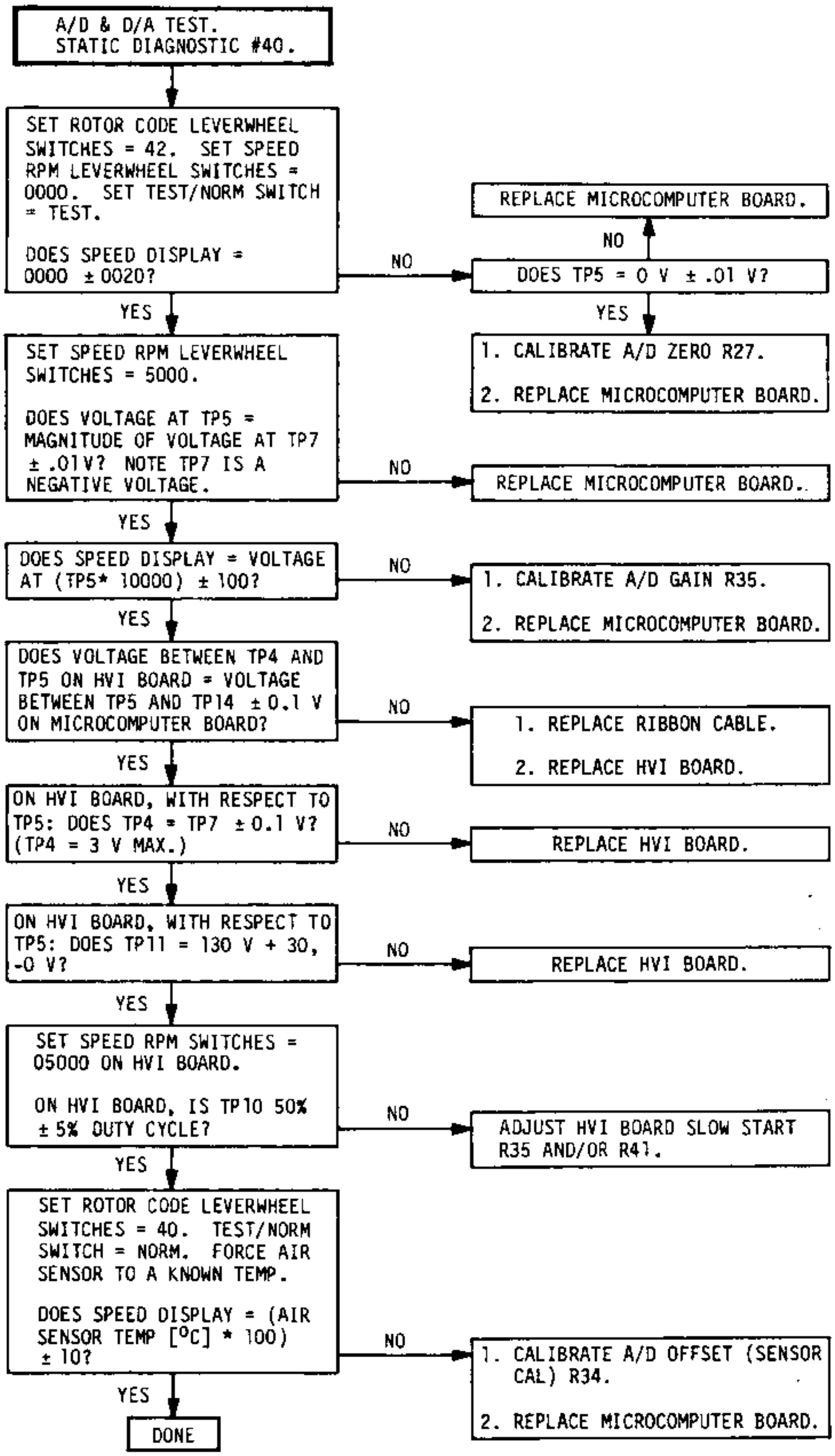


Table 10-9. A/D & D/A Test, Static Diagnostic #40 Troubleshooting Chart

NOTE

- ONCE START SWITCH IS PRESSED, TEST STATE LASTS FOR 9 SECONDS FOR EACH TEST.
- LOGIC HIGH = 3.4 ± 0.5 V.
- LOGIC LOW = 0.8 ± 0.2 V.

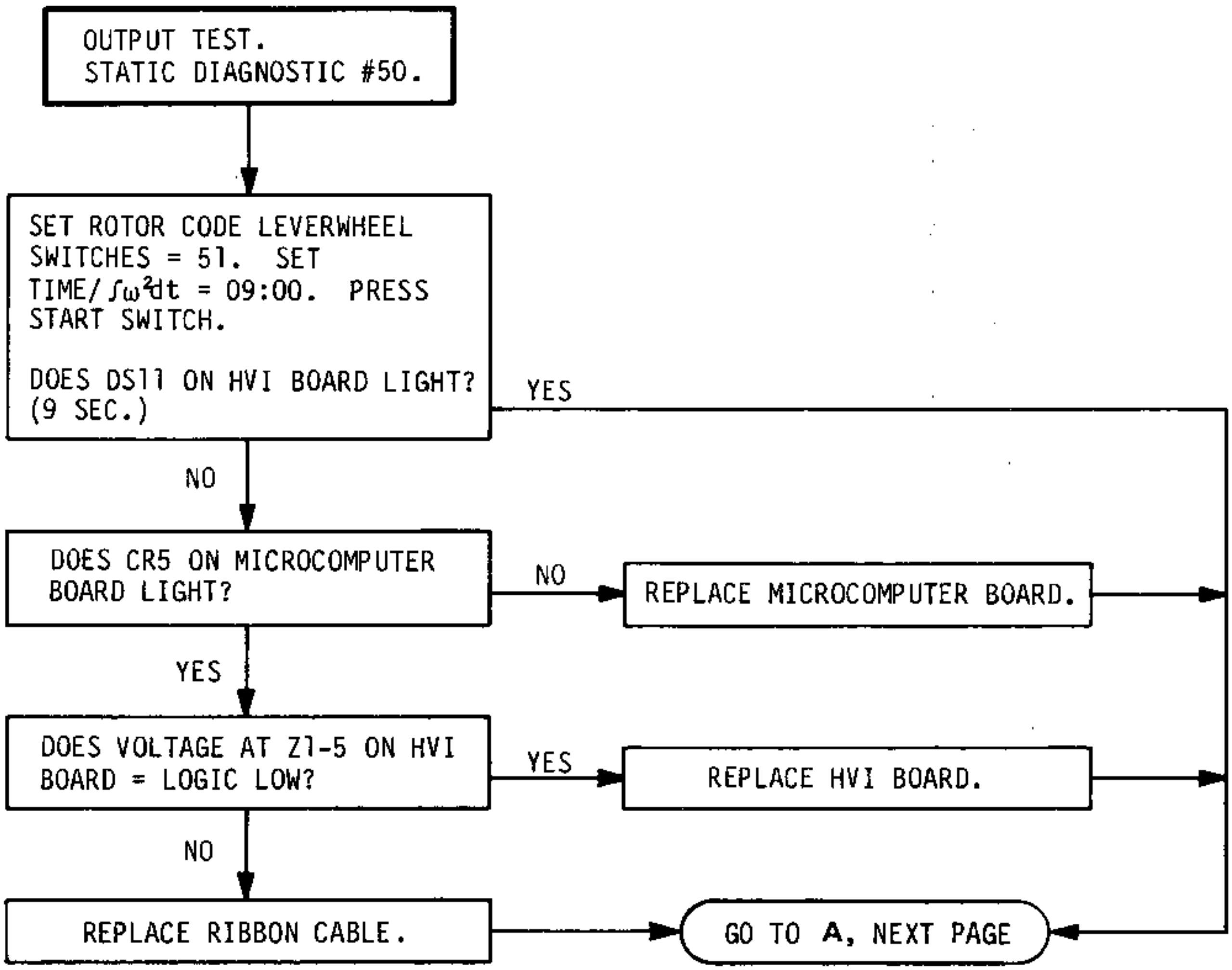


Table 10-10. Output Test, Static Diagnostic #50 Troubleshooting Chart
1 of 5

NOTE

- ONCE START SWITCH IS PRESSED, TEST STATE LASTS FOR 9 SECONDS FOR EACH TEST.
- LOGIC HIGH = 3.4 ± 0.5 V.
- LOGIC LOW = 0.8 ± 0.2 V.

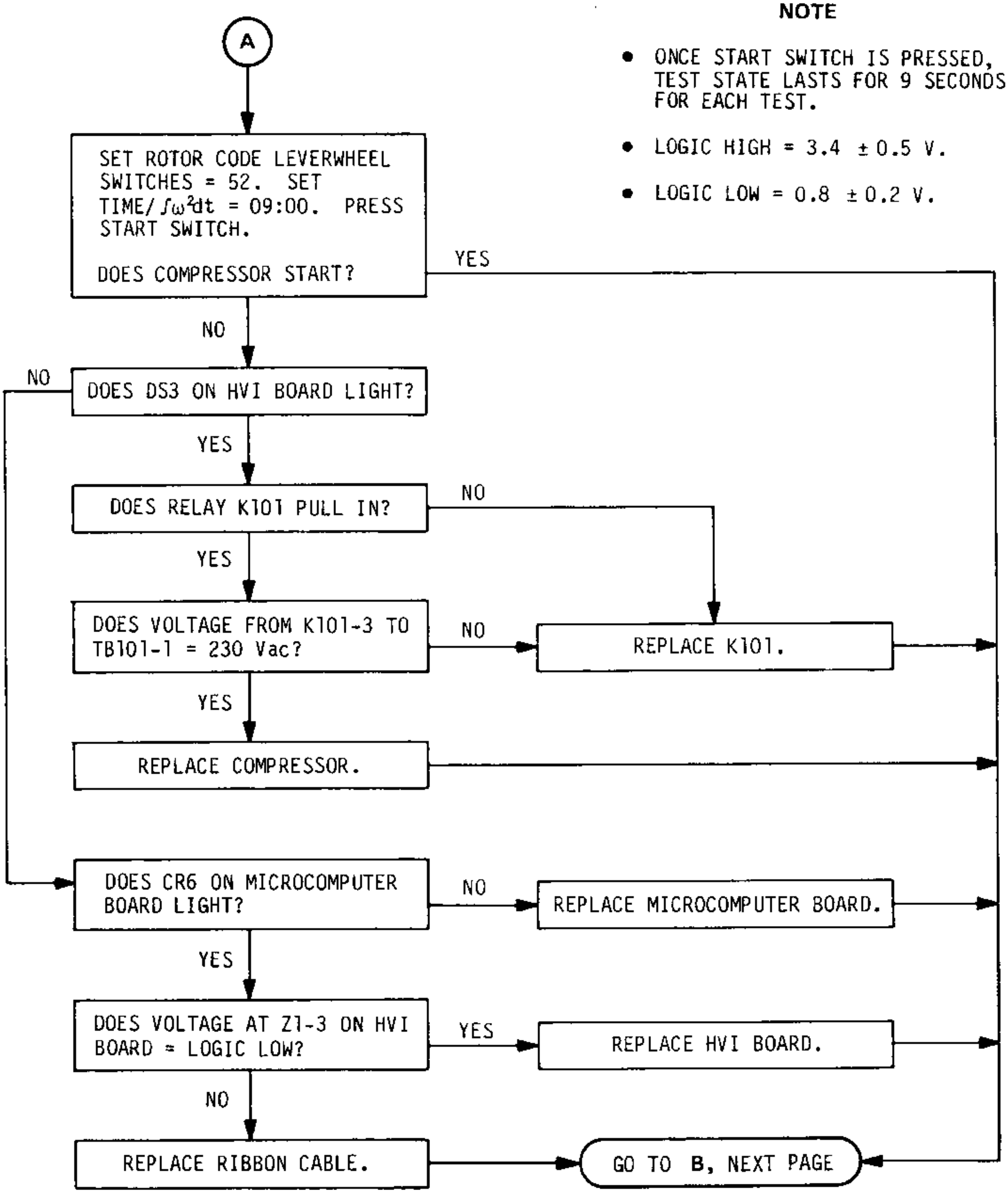


Table 10-10. Output Test, Static Diagnostic #50 Troubleshooting Chart
2 of 5

NOTE

- ONCE START SWITCH IS PRESSED, TEST STATE LASTS FOR 9 SECONDS FOR EACH TEST.
- LOGIC HIGH = 3.4 ± 0.5 V.
- LOGIC LOW = 0.8 ± 0.2 V.

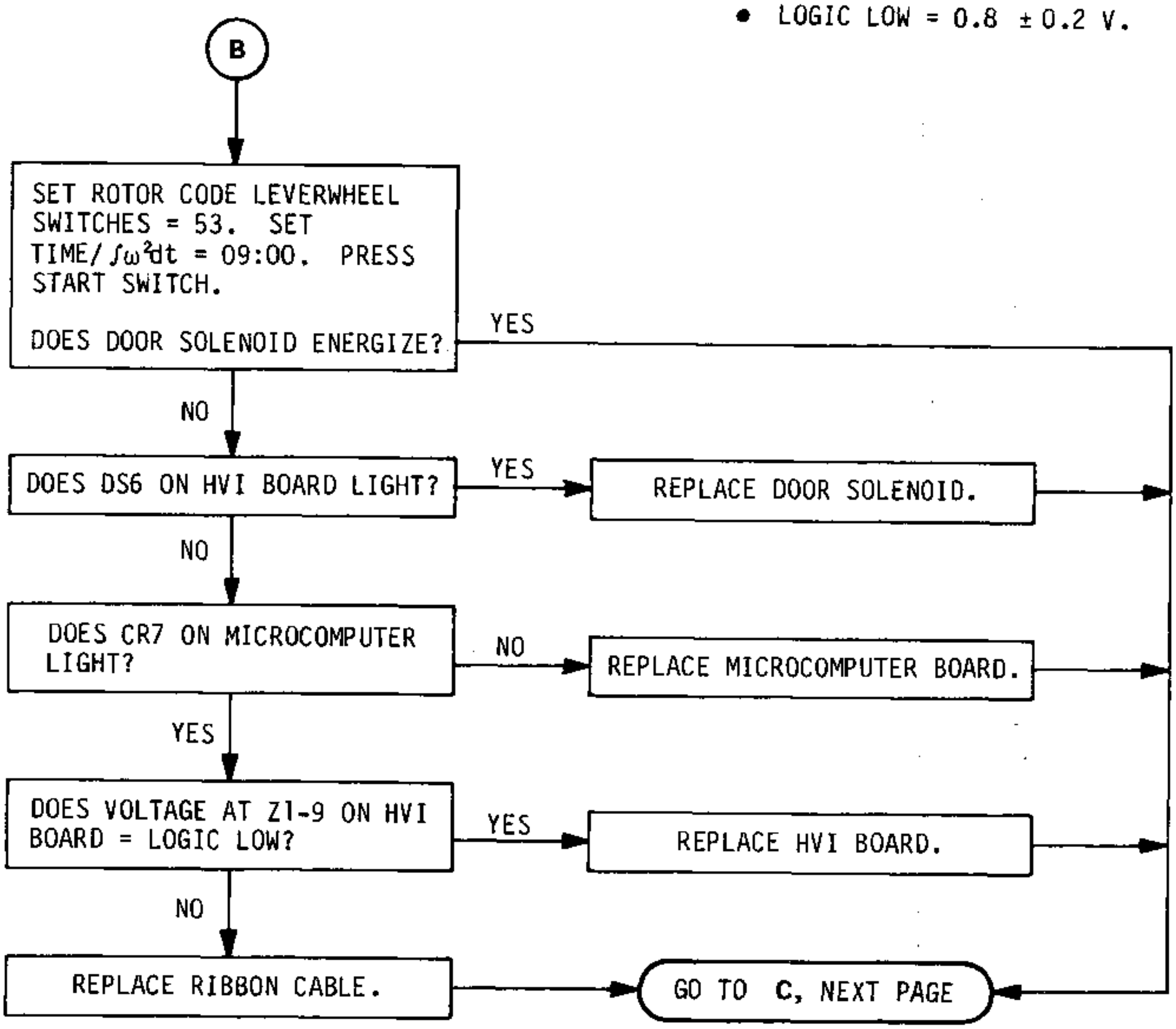


Table 10-10. Output Test, Static Diagnostic #50 Troubleshooting Chart
3 of 5

NOTE

- ONCE START SWITCH IS PRESSED, TEST STATE LASTS FOR 9 SECONDS FOR EACH TEST.
- LOGIC HIGH = 3.4 ± 0.5 V.
- LOGIC LOW = 0.8 ± 0.2 V.

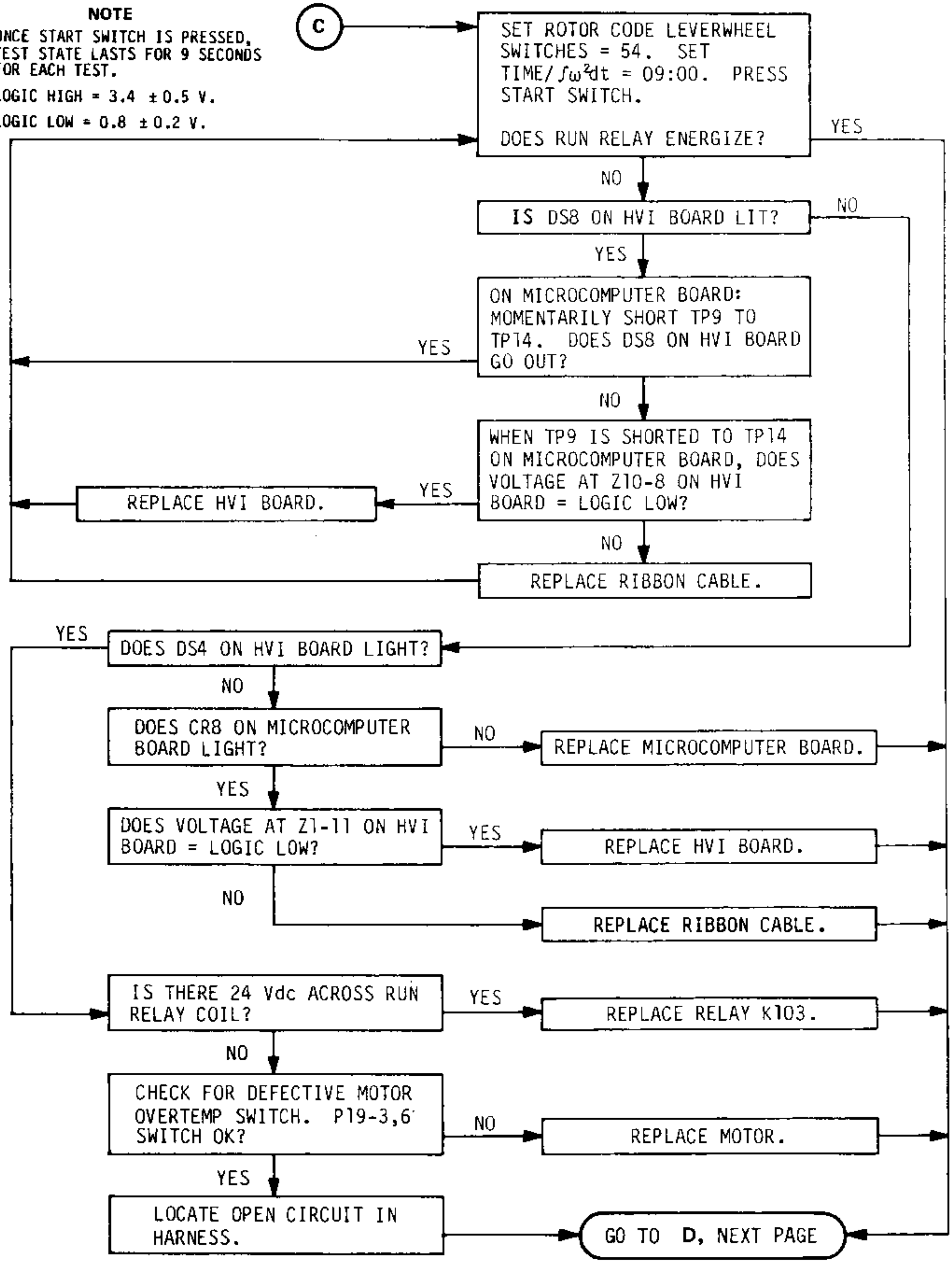


Table 10-10. Output Test, Static Diagnostic #50 Troubleshooting Chart
4 of 5

NOTE

- ONCE START SWITCH IS PRESSED, TEST STATE LASTS FOR 9 SECONDS FOR EACH TEST.
- LOGIC HIGH = 3.4 ±0.5 V.
- LOGIC LOW = 0.8 ±0.2 V.

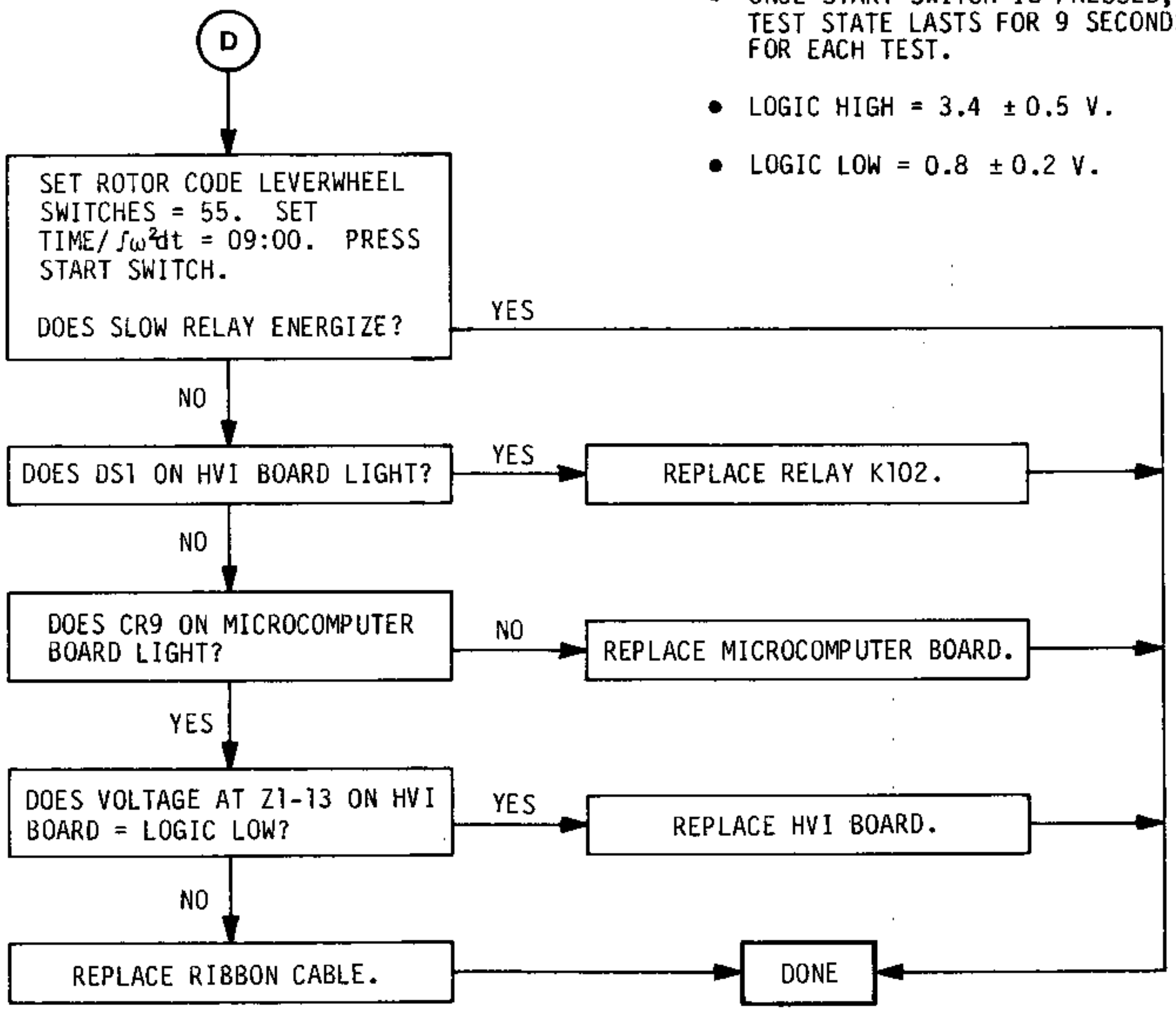


Table 10-10. Output Test, Static Diagnostic #50 Troubleshooting Chart
5 of 5

INPUT TEST
STATIC DIAGNOSTIC #60

The system inputs are related to the LED displays per the following table. Also listed is the source of the signal, the indicator on the HVI board, and the test point on the Microcomputer Board.

DISPLAY	SIGNAL SOURCE	LED DISPLAY	INDICATOR HVI BOARD	TEST POINT MICROCOMPUTER BOARD
TEMP x 10	HOLD/OFF SWITCH (S & I BOARD)†	0 1	--- ---	--- ---
TEMP x 1	∫ω²dt/OFF SWITCH (S & I BOARD)	0 1	--- ---	--- ---
RPM x 10K	Q4‡ (CURRENT LIMIT, HVI BOARD)	0 1	--- ---	--- ---
RPM x 1K	ZONAL/NORM (KEY SWITCH)	0 1	DS7=OFF DS7=ON	TP8=HIGH TP8=LOW
RPM x 100	Z22-7‡ (IMBALANCE, MICROCOMPUTER BOARD)	0 1	--- ---	--- ---
RPM x 10	Z4-8‡ (WORN BRUSH, HVI BOARD)	0 1	DS12=OFF DS12=ON	TP10=HIGH TP10=LOW
RPM x 1	RCF/RPM SWITCH (S & I BOARD)	0 1	--- ---	--- ---
TIME, HRS x 10	Z10-8 (FAULT MEMORY, HVI BOARD)	0 1	DS8=OFF DS8=ON	TP9=LOW TP9=HIGH
TIME, HRS x 1	ARC/OFF SWITCH (S & I BOARD)	0 1	--- ---	--- ---
TIME, MIN x 10	S102 & S103 (LATCH & DOOR)	0 1	DS6=OFF DS6=ON	TP11=HIGH TP11=LOW
TIME, MIN x 1	BRAKE/OFF SWITCH (S & I BOARD)	0 1	--- ---	--- ---

† Switches and Indicators Board.

‡ These inputs are not easily verified under STATIC DIAGNOSTIC control. Verify under normal operation.

FOR THE 5 SIGNALS WHOSE SOURCE IS THE S & I BOARD: IS CONTROL POSSIBLE?

NO → 1. REPLACE S & I BOARD.
2. REPLACE MICROCOMPUTER BOARD.

YES ↓

ARE LATCH & DOOR, AND KEY SWITCH INPUTS AS INDICATED?

NO → 1. REPLACE FAULTY SWITCH.
2. REPLACE HARNESS.

YES ↓

DONE

Table 10-11. Input Test, Static Diagnostic #60 Troubleshooting Chart

NOTE

DRIVE SYSTEM REMAINS ENERGIZED FOR ONLY A FEW SECONDS AFTER START IS PRESSED.

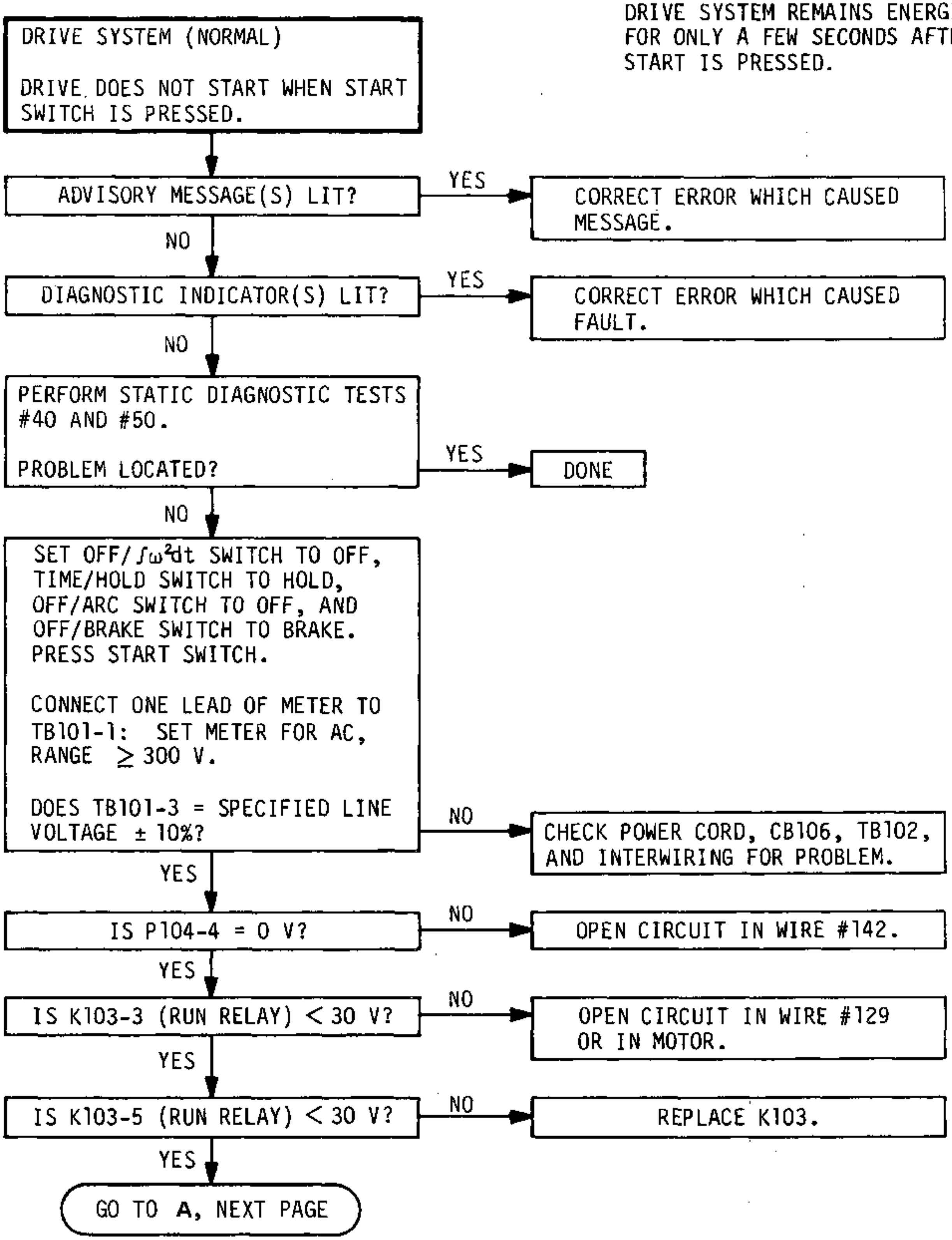


Table 10-12. Drive System (Normal) Troubleshooting Chart
1 of 2

NOTE

DRIVE SYSTEM REMAINS ENERGIZED FOR ONLY A FEW SECONDS AFTER START IS PRESSED.

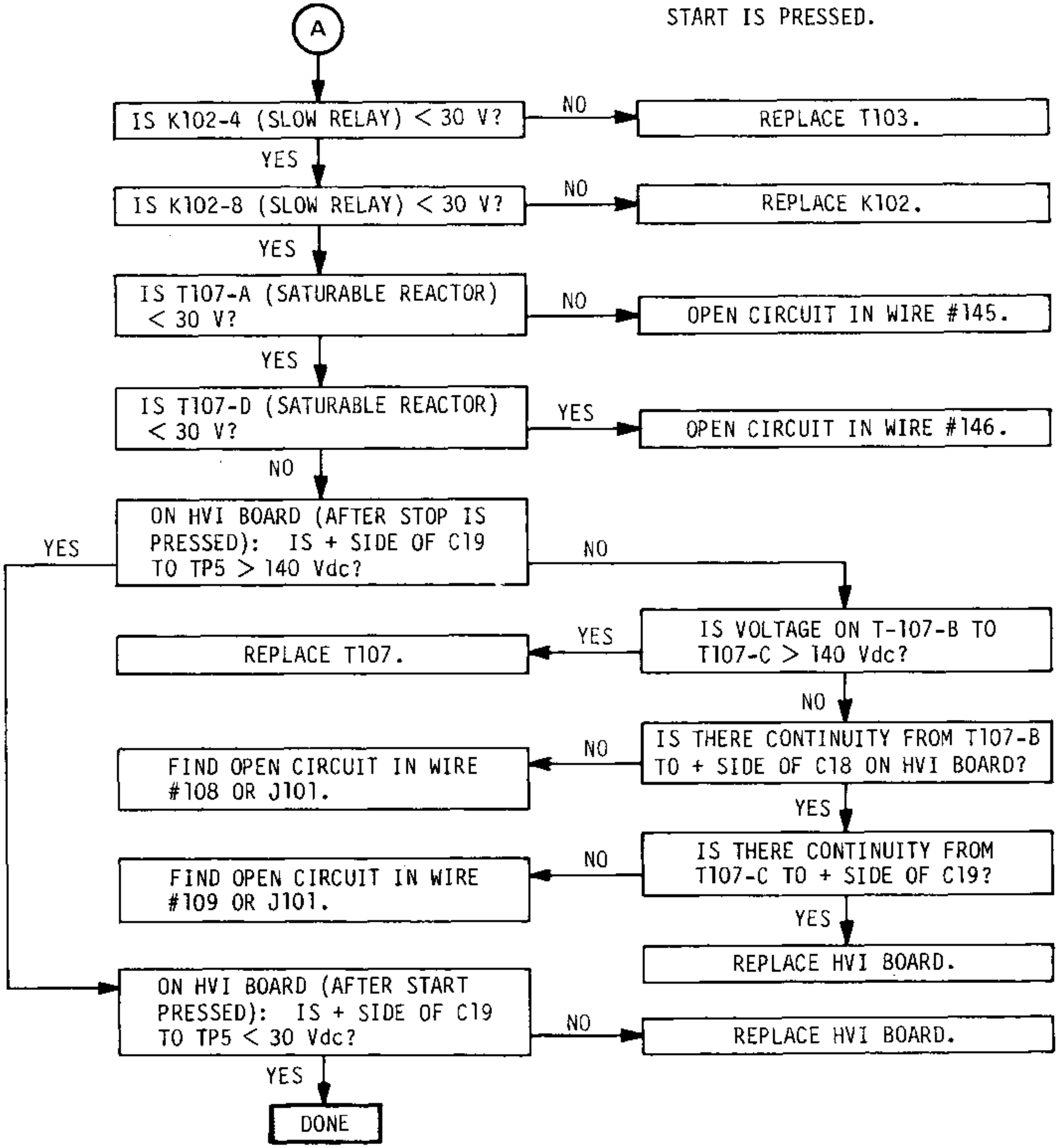


Table 10-12. Drive System (Normal) Troubleshooting Chart
2 of 2

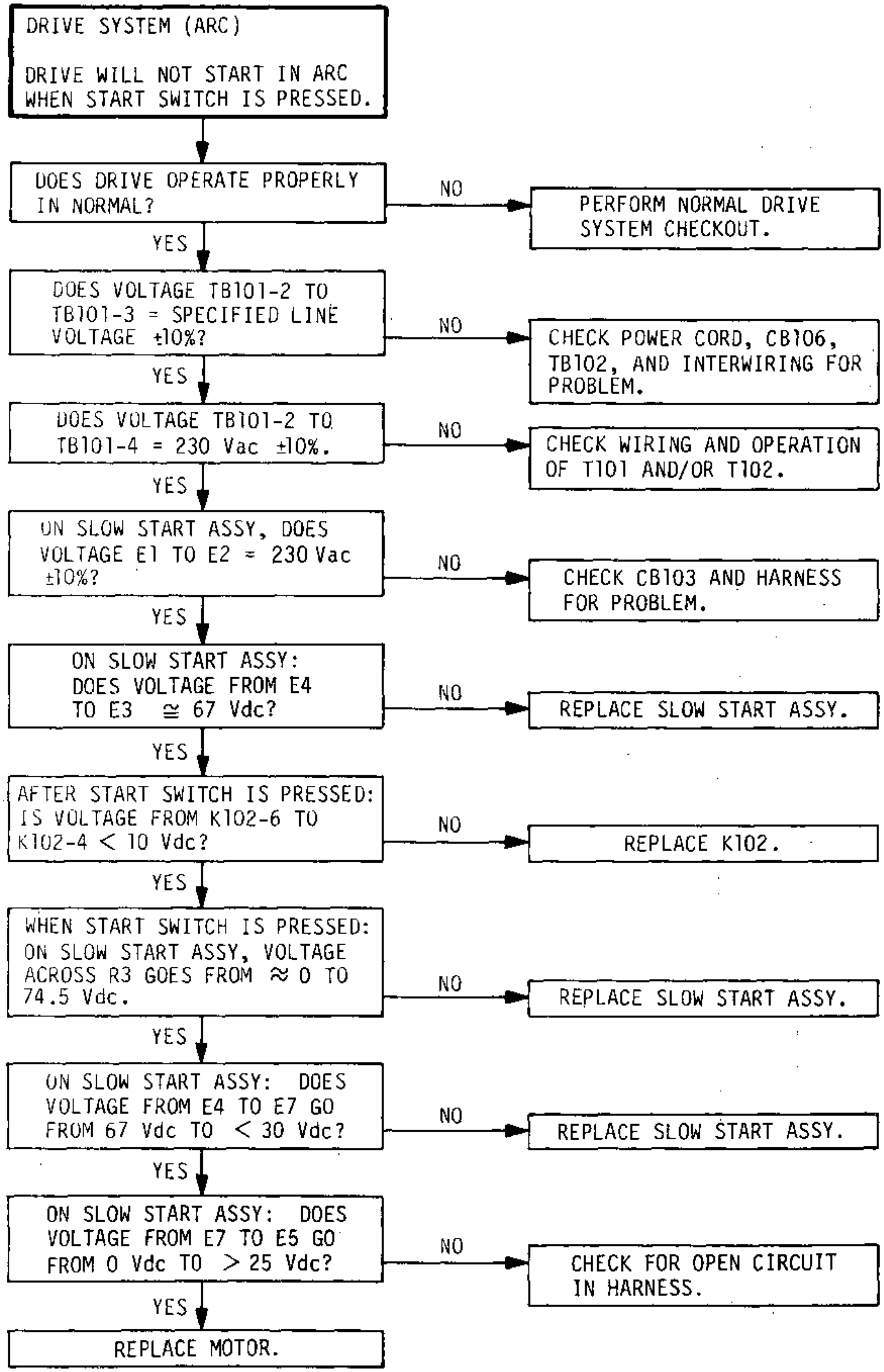


Table 10-13. Drive System (ARC) Troubleshooting Chart A

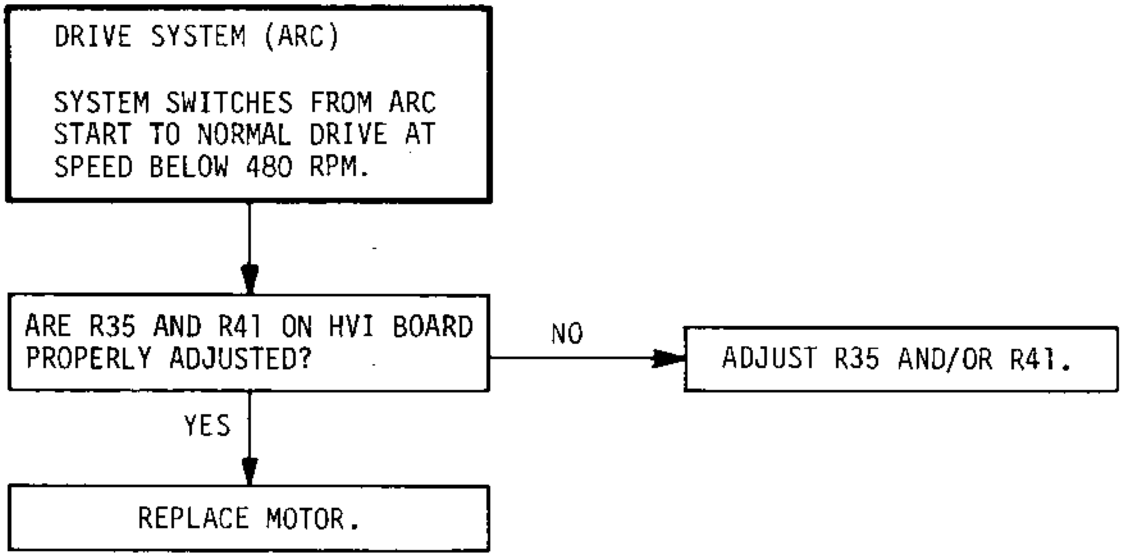


Table 10-14. Drive System (ARC) Troubleshooting Chart B

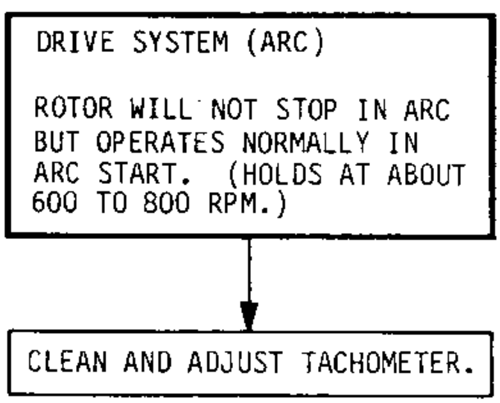


Table 10-15. Drive System (ARC) Troubleshooting Chart C

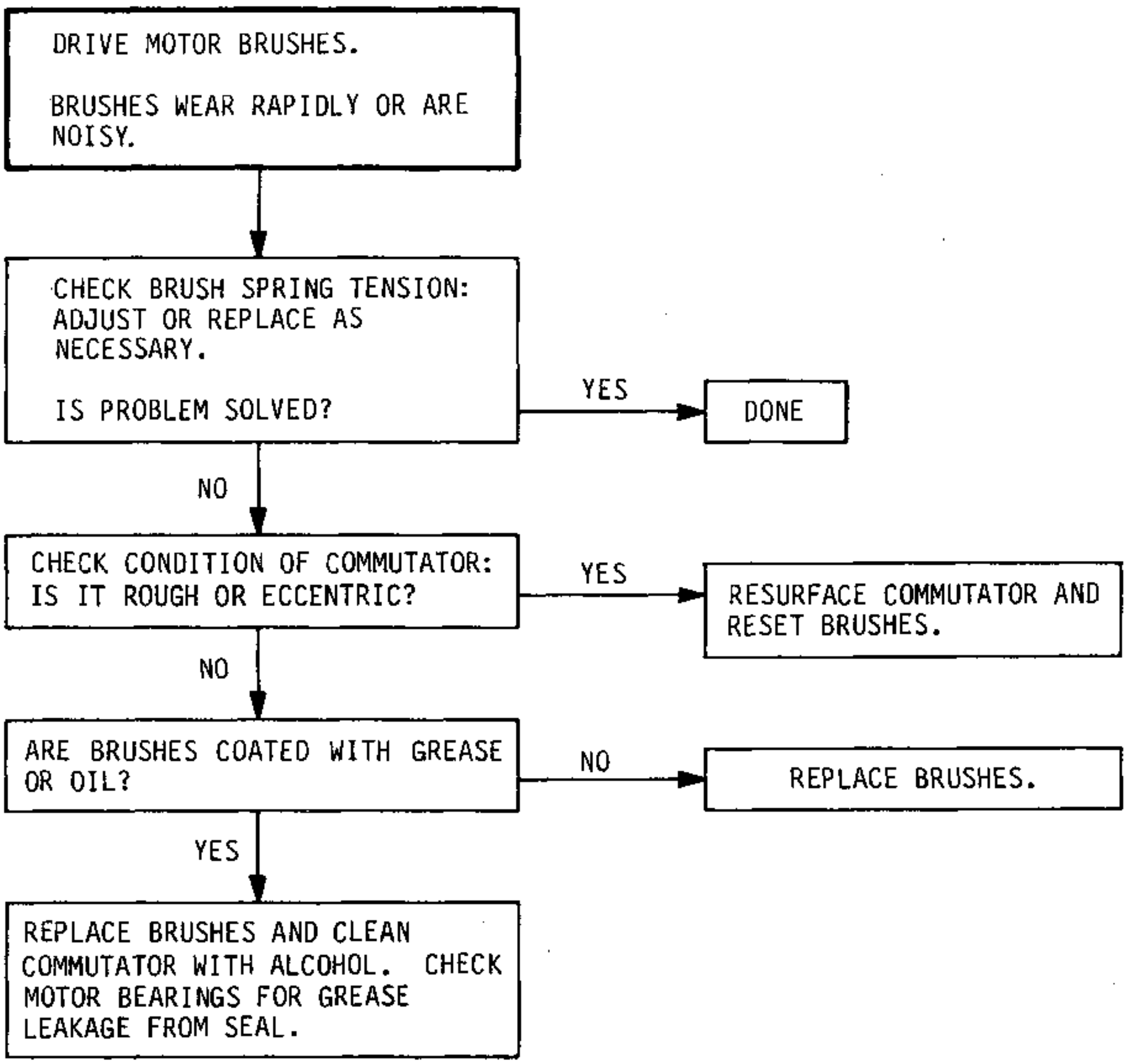


Table 10-16. Drive Motor Brushes Troubleshooting Chart

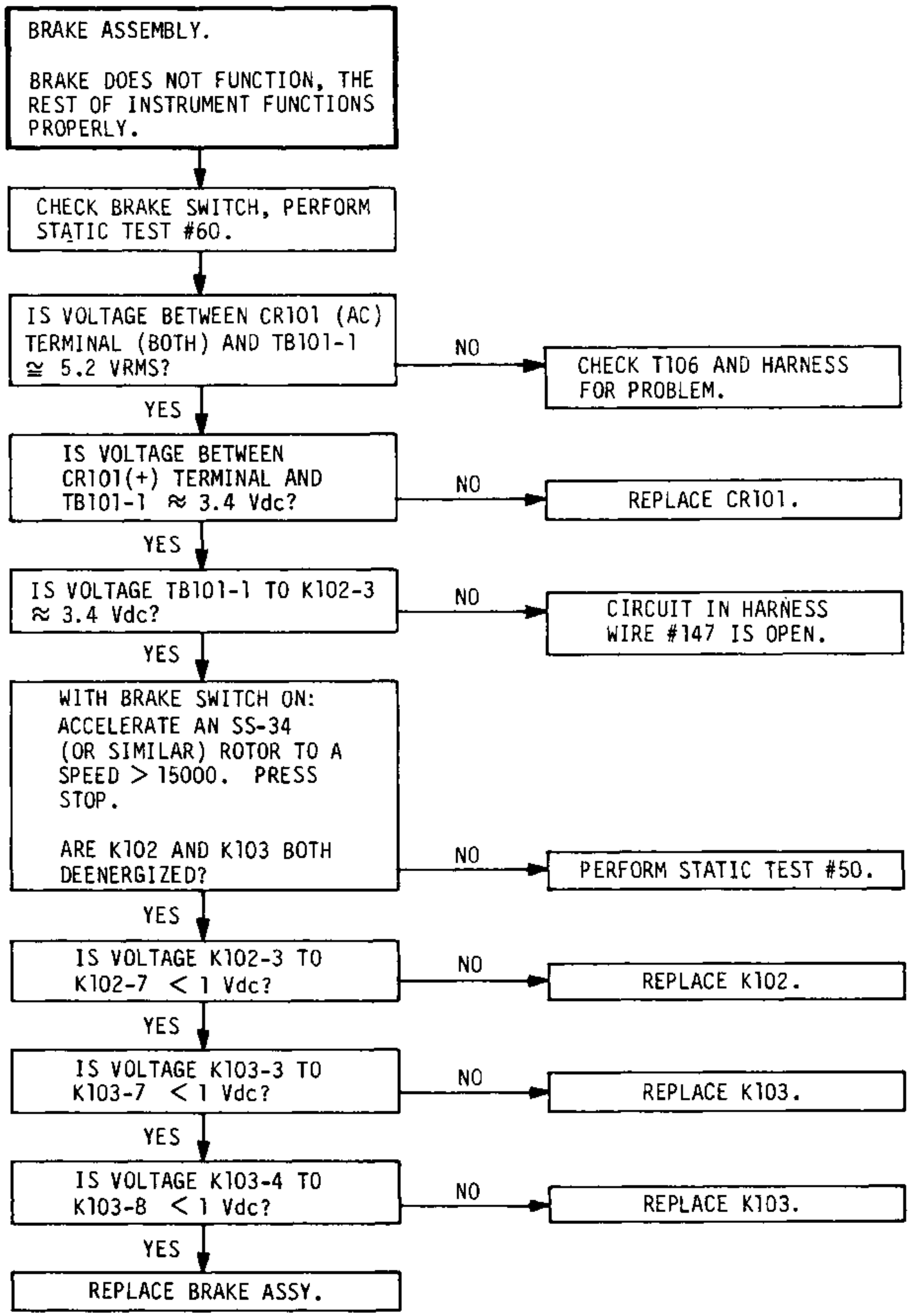
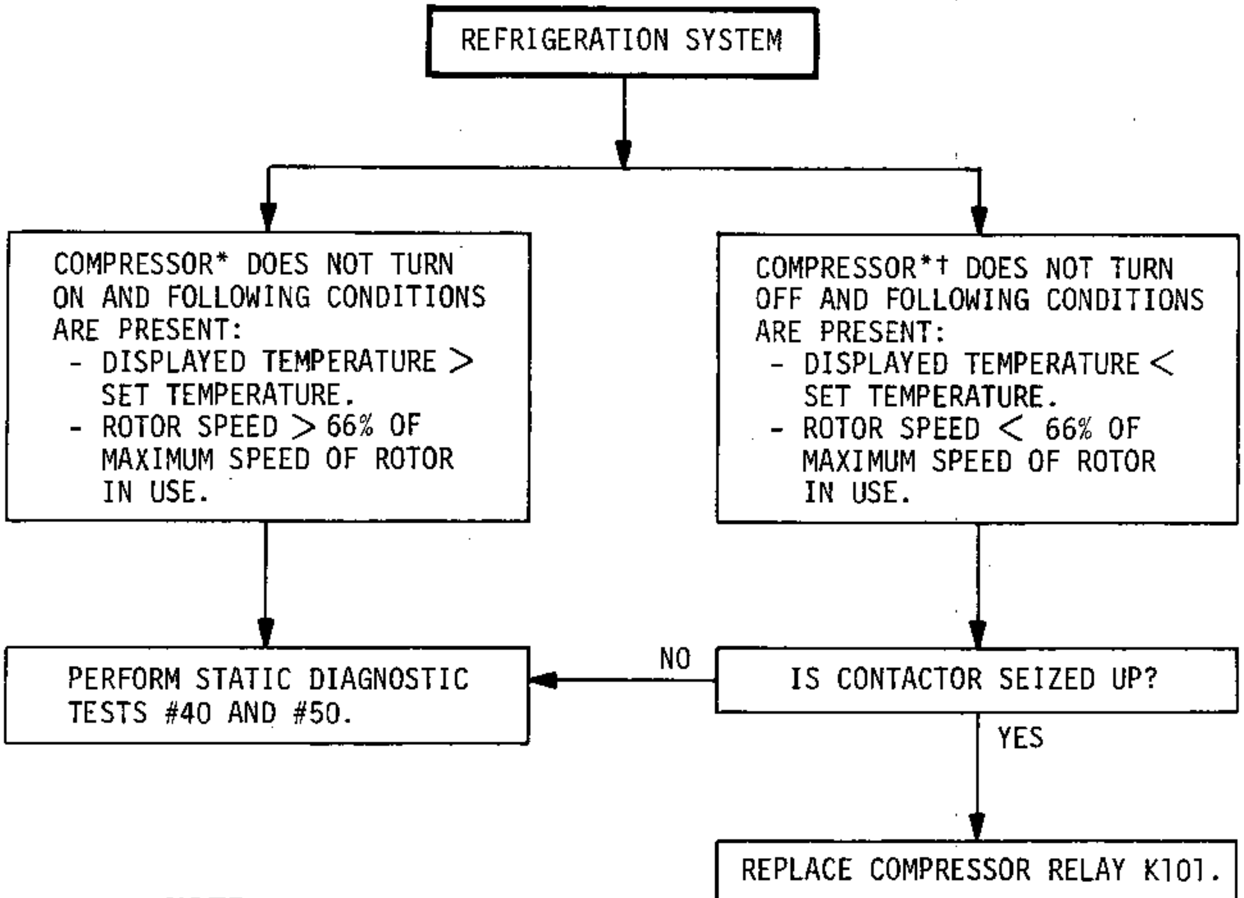


Table 10-17. Brake System Troubleshooting Chart



NOTE

* MAXIMUM COMPRESSOR ON TIME IS 2 MINUTES.

† MINIMUM COMPRESSOR OFF TIME IS 30 SECONDS.

Table 10-18. Refrigeration System Compressor Cycle Troubleshooting Chart

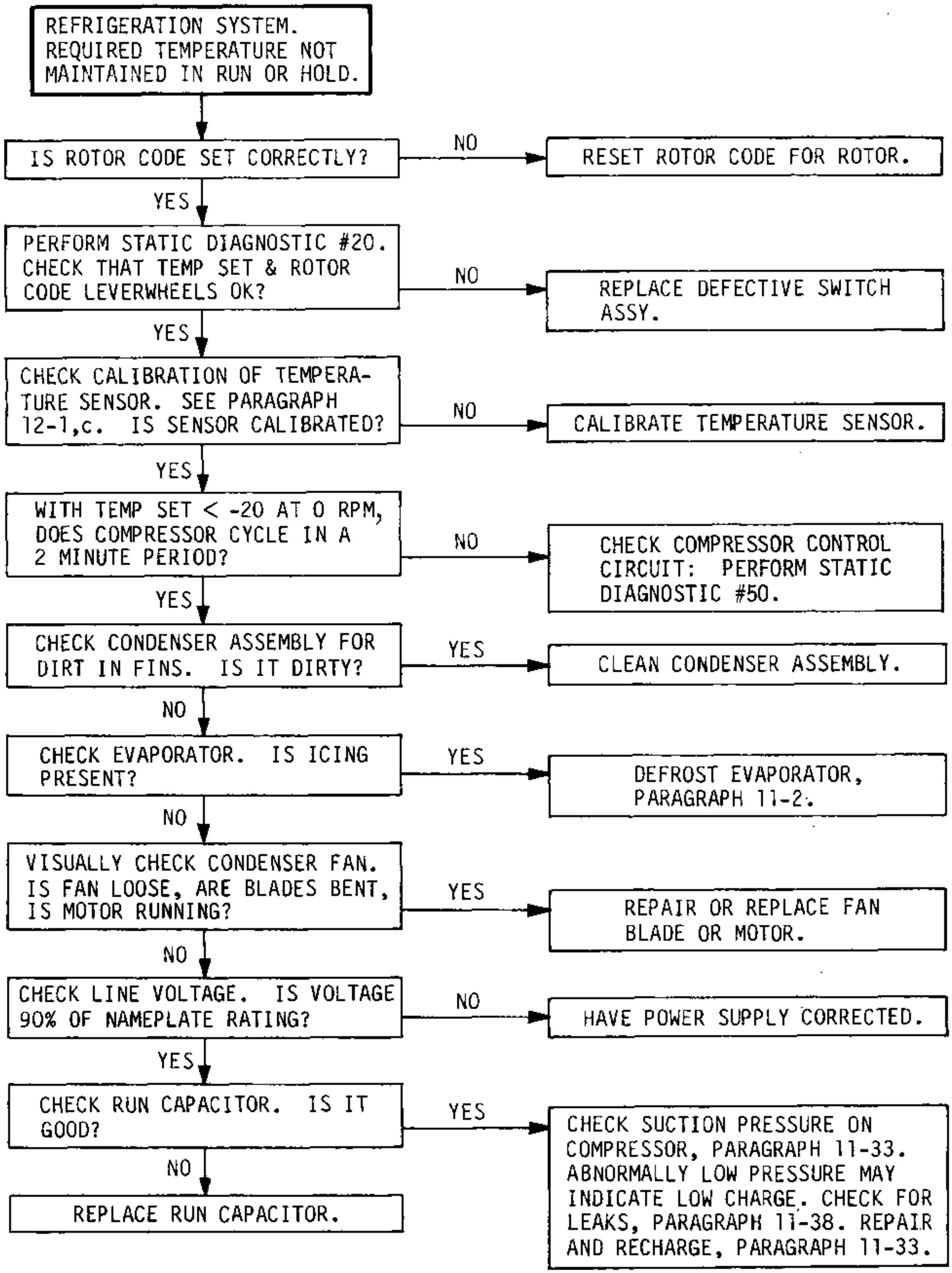
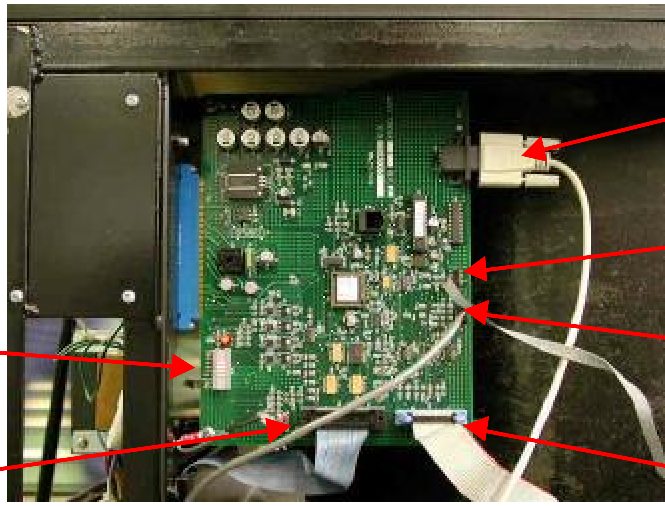


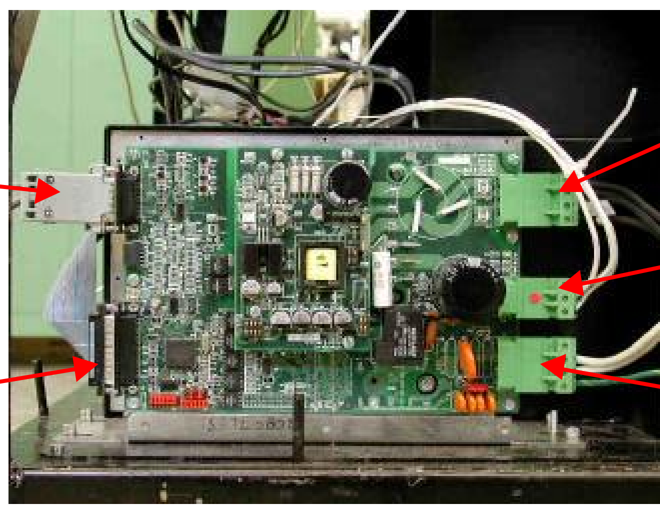
Table 10-19. Refrigeration System Temperature Control Troubleshooting Chart

RC-5C *Plus* Brushless Drive Troubleshooting:

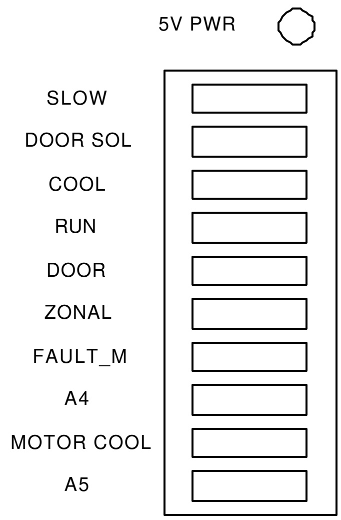
Troubleshooting problems with the RC-5C *Plus* brushless drive system can be achieved by observing the LEDs that are located on the Drive Interface board (see figure below). Information can also be obtained by connecting a computer to the Drive Interface board and viewing error messages using the computer's Hyperterminal program.



Drive Interface Printed Circuit Board



Drive Control Module



Diagnostic LEDs (located on the Drive Interface)

LED Indicators:

5v PWR: LED is lit when the Drive Interface has established 5 vdc power.

SLOW: This LED, is lit when the motor is to be placed in a coast mode or when the rotor has stopped moving altogether. It is also active concurrently with RUN_RY at the beginning of an ARC run.

DOOR SOL: This light is lit when the door solenoid is energized allowing the door to be opened.

COOL: This light is lit when the cooling compressor is running.

RUN: This LED is lit when the control system is commanding that torque be applied in the forward direction to the motor. When the LED is off, torque may be commanded (depending on other conditions) in the reverse direction or not at all.

DOOR: This light is lit when the door is open.

ZONAL: This light is lit when the ZONAL mode of operation is active.

FAULT M: This is a latched signal that indicates a fault has been detected by the main control processor. This signal gates the RUN_RY signal so that if a fault has been set, the PIC cannot see RUN_RY become TRUE. This signal is not directly observed by the PIC. It is only indirectly observed by its gating function on the RUN_RY signal.

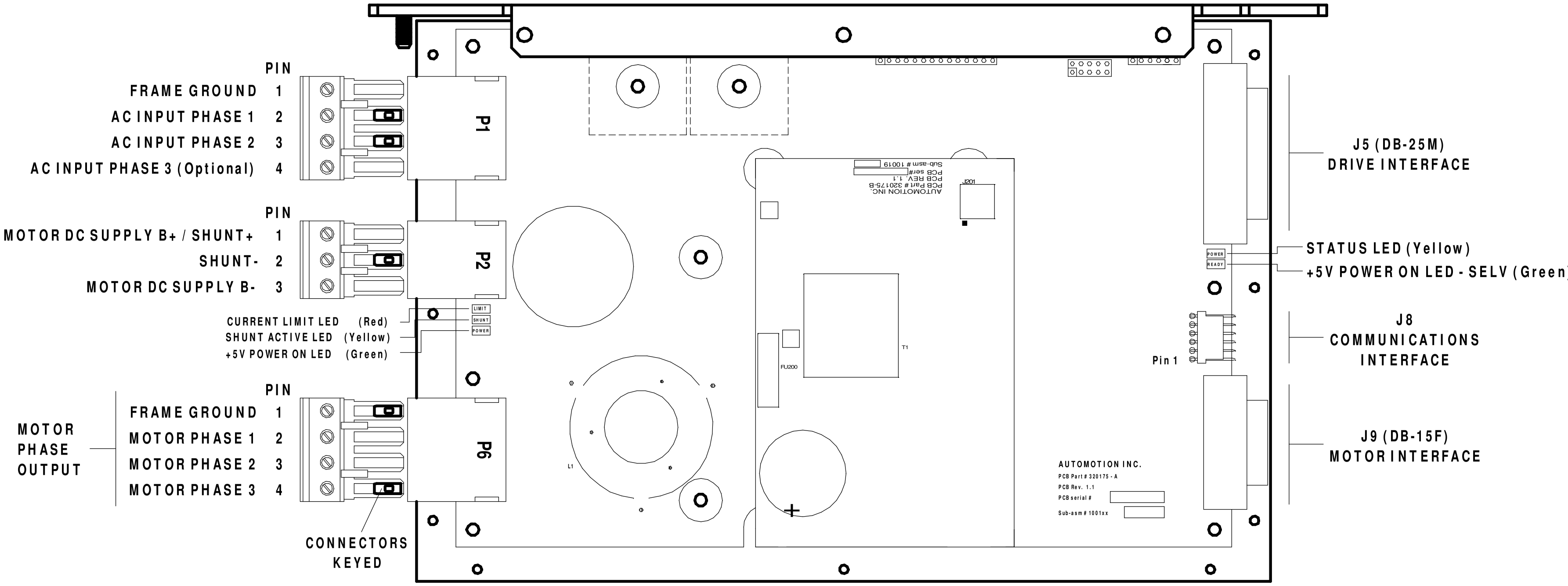
A4: The Safety PIC controls two LED indicators, which it uses to show the user when it detects a fault. When the drive interface board in mounted in a system, these LEDs are located in the lowest and third from lowest positions on the LED bar containing the various indicator LEDs. The lowest LED is designated A5 and the third from the bottom is designated A4.

MOTOR COOL: This LED is lit when the motor cooling fan is operating.

A5: The Safety PIC controls two LED indicators, which it uses to show the user when it detects a fault. When the drive interface board in mounted in a system, these LEDs are located in the lowest and third from lowest positions on the LED bar containing the various indicator LEDs. The lowest LED is designated A5 and the third from the bottom is designated A4.

A4	**A5**	**Condition**	**Possible Cause**
Off	Off	No Fault	N/A
Off	On	Timeout Seizing	Drive PIC Detected Fault in Tach or Overtemp (likely to be cable connection problem)
On	Off	Drive Box Fault	N/A (Not Monitored)
On	On	Tachometer Disagree (detected at speeds above 2,000 rpm)	Cabling or Motor Commutation Board Failure (Check cable connection J-9. If OK replace Motor)
Flash	Off	Motor Overtemp	Cabling failure or Motor Overtemp
Off	Flash	Timeout Releasing Loss of communication between the Safety PIC and the Drive PIC	Drive Interface Board (Replace the Drive Interface Board)
Flash	On	Not Defined	N/A
On	Flash	Duty Cycle Violation	Failure on Drive PIC (Replace the Drive Interface Board)
Synchronized Flash	Synchronized Flash	PWM Signal Pegged High	Failure on Drive Interface Board (Replace the Drive Interface Board)
Alternating Flash	Alternating Flash	Error in Ke Memory	Cabling or Motor Ke Memory Failure (Check cable connection J-4. If OK replace Motor)
Alternating Flash on for one second	Alternating Flash on for one half second	Bad Message from Drive PIC	Drive Interface Board (Replace the Drive Interface Board)

REV.	DESCRIPTION	INIT.	DATE
0	PRODUCTION RELEASE.	JRW	04/25/02
1	ADDED LED DESCRIPTION.	JRW	08/04/04



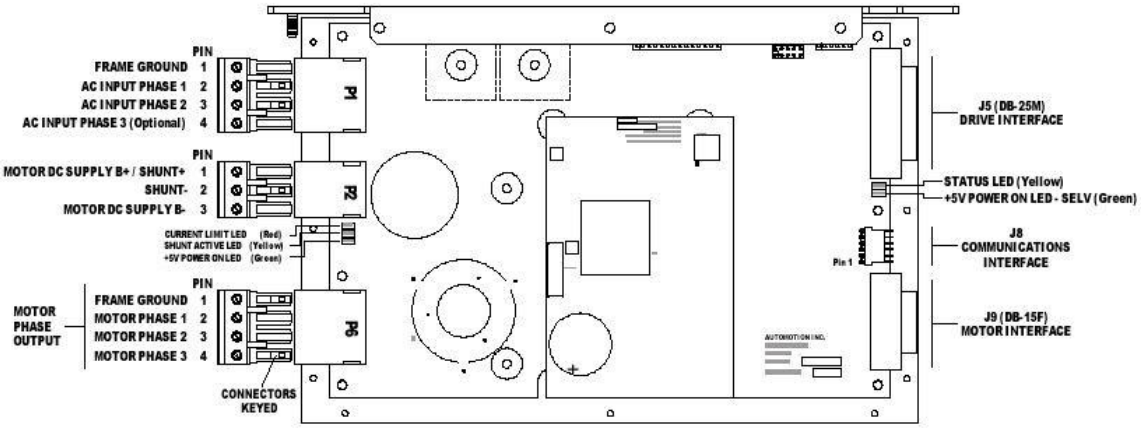
Status LED flash Codes (yellow)
ON Steady - Drive in RUN mode (No Faults)
OFF Steady - Drive in Reset
1 - Standby Mode (No Faults)
2 - Power Module Fault
3 - B+ Rail Voltage too High
4 - B+ Rail Voltage too Low
5 - User +5V Supply Out of Tolerance
6 - Processor Communication Timeout
7 - Phase to Ground Fault
8 - Internal Logic Supply Out of Tolerance
9 - Memory Fault

Shunt LED (yellow)
ON / Blinking - Shunt Active, B+ Rail Above +437VDC
OFF - Shunt Not Active, B+ Rail Below +425VDC

Current Limit LED (red)
ON / Blinking - Current Limit Active (either AC Inrush or Motor Current)
OFF - Current Limit Not Active

ACE CONNECTOR OUTLINE

DRAWN BY	J WAHL	DATE	04/25/02
DRAWING APPROVAL	ED WILHELM	DATE	08/04/04
CHECK APPROVAL		DATE	
ASSY. #		PCB PART #	
PCB REV.	PROD. REV. 1	LAST DRAW. REV.	08/04/04
FILENAME	A10778.CAD	SHEET	1 of 1
AUTOMOTION INC.		DRAWING #	A10778



LED	Description	
Current Limit LED (Red)	ON / Blinking: Current limit is active (either AC Inrush or motor current) OFF: Current limit not active	
Shunt Active (Yellow)	ON / blinking: Shunt active, B+ rail above 437 vdc. OFF: Shunt not active, B+ rail is below 425 vdc	
+5 v power LEDs (2 green LEDs)	+ 5 volt power supply is active. This LED should always be on.	
Status LED (Yellow)	Displays flash codes to inform of drive status.	
	ON Steady	Drive in RUN mode (no faults)
	OFF steady	Drive in reset
	1 flash	Stand by mode (no faults)
	2 flash	Power Module fault
	3 flash	B+ rail voltage too high
	4 Flash	B+ rail voltage too low
	5 flash	Centrifuge low voltage power supply out of tolerance
	6 flash	Processor Communication time out
	7 flash	Phase to ground fault
	8 flash	Internal logic supply out of tolerance
	9 flash	Memory fault

RC-5C *Plus*
Table of Contents

6.0 Repair & Replacement

RC-5C *Plus* Repair and Replacement Procedures

Warning:

Because of high voltage in the centrifuge, untrained personnel must not attempt to test or repair any electrical circuits in it. Service personnel must read and understand the theory of operation before servicing the centrifuge.

Warning:

To remove the potential of electrical shock, set the main circuit breaker, POWER switch, to OFF and disconnect the main power cord from the power source. The terminals of the circuit breakers are always energized when the power cord is connected.

Warning:

If the centrifuge has been used with radioactive or pathogenic samples, there is the possibility that radioactive or biological contamination may have occurred. Appropriate precautions and decontamination procedures must be followed.

RC-5C *Plus* Service Manual
Repair & Replacement Procedures

CABINET PANEL REMOVAL AND REPLACEMENT

This procedure pertains to RC-5C, RC-5C+, & RC-5C+ Brushless centrifuges

To access the internal components of the centrifuge, the panels of the centrifuge cabinet must be removed. The panels can be removed in any order.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the power supply.

3. Remove front, right, and left cabinet panels as follows:

    a. Loosen and disengage the two screws in the upper recess of the panel beneath the top deck cover. Figure 11-2.
    b. Carefully move the top of the panel away from the cabinet.
    c. Lift the panel up and slip the lower edge of the panel off the locating pins.

4. Remove rear cabinet panel as follows:

    a. Loosen the 3 screws and star washers located on each side of the rear panel. Figure 11-2. (Total of 6 screws and star washers.)
    b. Carefully lift the panel up and away from the cabinet. Be sure and clear the strain relief of the power cord.

5. Reinstall the panels by reversing above steps.

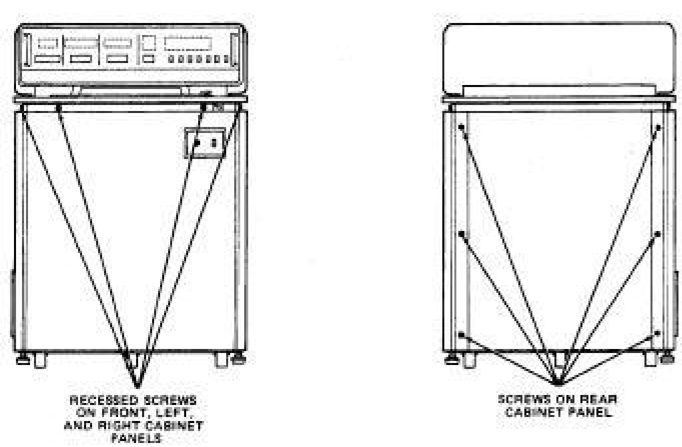


Figure 11-2. Location of Front and Rear Panel Screws

DRIVE MOTOR AND GYRO-ACTION DRIVE REPLACEMENT:

This procedure is to be used on RC-5C, RC-5C Plus, & RC-5C Plus brushless centrifuges.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the mains power supply.

3. Remove the front cabinet panel.

4. Disconnect 3 motor plugs P/J 31, 104, and 119 from main harness. Figure 11-3.

5. Remove the lower half of noise suppressor. Figure 11-3, as follows.

Note:

On RC-5C Plus centrifuges the silencer assembly consists of one piece. Disregard step #5. The motor can be removed by pulling it out of the top of the silencer assembly.

Caution:

On RC-5C centrifuges do not bend the air intake duct. It must be moved away from the noise suppressor. The aluminum casing inside the duct can break and release fiberglass insulation, which can be drawn into the motor and cause overheating.

a. Loosen the two screws on air intake duct mounting plate. The right rear screw hole is slotted and allows the plate and air duct to be removed and pivoted on the remaining screw.
b. Pivot the air intake duct and mounting plate away from the lower half of the noise suppressor.
c. Release clamps attaching lower and upper parts of noise suppressor.
d. Detach lower half of the noise suppressor.

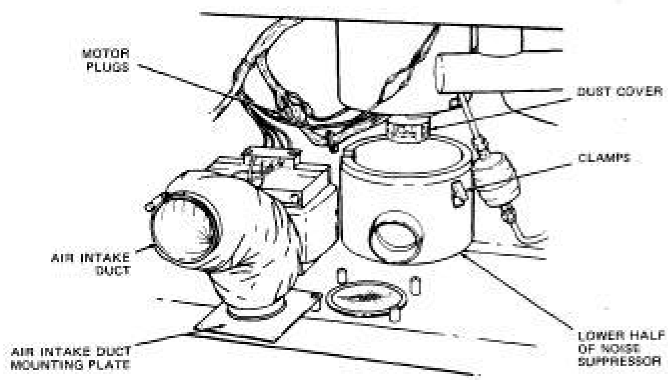


Figure 11-3. Location of Motor Plugs and Noise Suppressor

6. Using the door lock override button, open the centrifuge chamber door.

7. Remove the drive motor and gyro-action drive as follows:

   a. Remove the rubber boot surrounding the drive in the base of the centrifuge chamber.
   b. Remove the foam padding beneath the rubber boot.
   c. Disconnect the imbalance detector wire, P/J 107, on top of the gyro.
   d. Using a 5/32 inch Alien wrench, completely loosen the 4 outer screws on the base. Leave screws in place.
   e. Lift the gyro-action drive and drive motor assembly out of the centrifuge: use a straight, upward motion being careful not to pinch or chafe cables. Guide the motor cords and plugs through the noise suppressor.

Caution

Do not pinch or chafe imbalance detector cable when removing the gyro-action drive and drive motor assembly.

8. Separate the drive motor and gyro-action drive assembly as follows:

   a. Lay drive motor and gyro-action drive assembly on a work surface and turn it so the service access hole in lower part of the gyro, between the two mounting plates, faces up.
   b. Rotate the gyro shaft by hand until the drive coupling clamping screw becomes visible through the service access hole.
   c. Loosen drive coupling damping screw with a 7/64 inch Alien wrench.
   d. Mark the orientation of the gyro to the motor.
   e. Remove three 5/32 inch Alien head screws holding the gyro to the motor.
   f. Separate the drive motor and gyro-action drive.

9. Repair drive motor or gyro-action drive, or obtain new assemblies for installation.

10. Reassemble the drive motor and gyro-action drive assembly as follows:

    a. Position the gyro-action drive on the drive motor (note correct orientation from step 8d) and secure with three 5/32 inch Alien head screws.
    b. Hold the motor shaft stationary and rotate the tapered spindle until the shaft is fully seated in the drive coupling. Turn the motor shaft until the drive coupling clamping screw is visible through the service access hole.
    c. Tighten the drive coupling clamping screw with a 7/64 inch Alien wrench to 20 inch "Ibs.

11. Reinstall drive motor and gyro-action drive assembly as follows:

    a. Lead the cords and plugs of the drive motor and gyro-action drive assembly through the base of the centrifuge chamber.
    b. Align the motor mounting plate over the guide pin in the rim of the chamber hole (3 o'clock position).

Caution:

The motor mounting plate of the assembly must be aligned in this manner. The assembly can be screwed in place without being aligned, but it will be unstable and the rotor will operate unbalanced at a dangerous angle.

    c. Tighten mounting screws until all 4 screws are firmly tightened.
    d. Reconnect the imbalance detector plug P/J 107.
    e. Replace the foam padding on the gyro base.
    f. Replace the rubber boot, making sure the lip is fully engaged around the gyro liner rim.

Caution:

An incomplete seal between the rubber boot and the gyro base can allow moisture to enter and damage the drive motor assembly.

Caution:

Insure that the foam ring that secures around the motor on the brush type motors is correctly in place. Failure to secure the ring properly will cause the motor to overheat and ultimately cause motor failure.

12. Reach up into the upper half of the noise suppressor and tuck the foam liner up and around the drive motor so that air flow into the bottom of the drive motor is not restricted.

13. Reinstall the lower half of the noise suppressor (on RC-5C centrifuges).

14. Reconnect the drive motor plugs P/J 31, 104, and 119 to the main harness.

15. Reinstall the air intake duct.

16. Reinstall the front cabinet panel.

DRIVE COUPLING REPLACEMENT:

This procedure is to be used on RC-5C and RC-5C Plus, & RC-5C Plus brushless centrifuges.

1. Remove and separate the drive motor and gyro-action drive assemblies as outlined in the motor replacement procedure.

2. Remove the foam insulator from around the bearing preload cap.

3. Remove the 3 motor standoff screws that hold the bearing preload cap in place. Figure 11-4. Lift the cap off.

Note:

Mark the orientation of the bearing preload cap to the motor before removing it.

4. Using a 7/64 inch Alien wrench, loosen the lower clamping screw in the drive coupling and remove the coupling.

5. Obtain and install a new drive coupling as follows:

   a. Press downward on the motor armature to ensure that the lower armature bearing is fully seated in the bearing housing.
   b. Seat the drive coupling on the motorshaft and tighten the bottom damping screw to 2.26 N'm (20 inch Ibs.) torque. When the height of the coupling is properly adjusted, the Alien wrench lays flat across the top face of the motor housing. Figure 11-5.

6. Install the bearing preload cap and secure it with the 3 motor standoff screws. Note the correct orientation of the bearing preload cap, step 3.

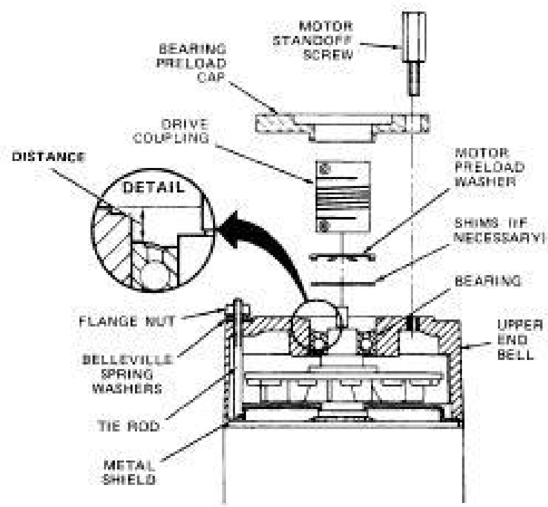


Figure 11-4. Motor Assembly

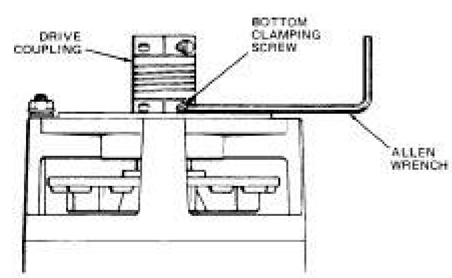


Figure 11-5. Drive Coupling Installation

7. Install the foam insulator around the bearing preload cap.

8. Reassemble the drive motor and gyro-action drive assemblies. See motor replacement procedure, step 10.

DRIVE MOTOR ARMATURE REPLACEMENT:

This procedure is to be used on RC-5C and RC-5C Plus, centrifuges using brush type motors. The armature can not be replaced on brushless motors.

1. Remove the motor drive and gyro-action drive assembly from the centrifuge and separate. See motor replacement procedure.

2. Remove drive motor armature assembly from motor housing as follows:

   a. Remove the carbon contact brushes.
   b. Remove the drive coupling. See motor coupling replacement procedure.
   c. Remove the dust cover from the bottom of the motor.
   d. Remove the locking nut for the tachometer optical disc and remove the disc. Figure 11-6.
   e. Remove the flange nuts and Belleville spring washers from the two motor tie rods and lift the upper end bell off. Figure 11-4.

Note:

Scribe locating marks on motor end bells for proper location for re-assembly.

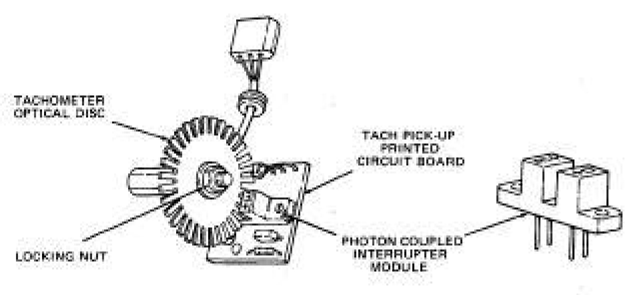


Figure 11-6. Tachometer Optical Disc

   f. Pull the armature assembly from the motor housing and remove the tachometer adapter from the armature shaft. Figure 11-7.

Note:

If using current assembly, clean the commutator bars with alcohol; after they have been cleaned, do not touch them again.

3. Reinstall the tachometer adapter to either the new or old assembly; do not over tighten it.

4. Position drive motor armature assembly in motor housing as follows:

Note:

On RC-5C brush motors (fan on the armature shaft) ensure that the metal shield is in place before installing the assembly. Figure 11-4.

a. Insert the armature into the motor housing.
b. Position upper end bell on motor (note correct orientation). Place the two Belleville spring washers on each motor housing tie rod; tighten flange nuts equally, then back off 1/4 turn. Figure 11-4.

5. Install the armature as follows: - If an old armature is installed:

a. Install shims on top of upper bearing.

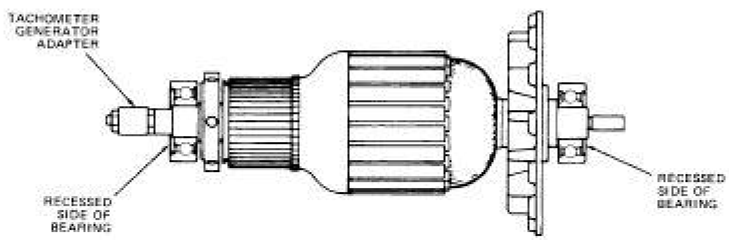


Figure 11-7. Armature Assembly

b. Install preload spring washer on top of shims. - If a new armature is installed:

Make sure the armature is fully seated in the lower end bell, then measure and record the distance between the outer race of the bearing and the upper end bell. Figure 11-4. Subtract 0.655 cm (0.262 in.) from the recorded value. The remainder is called the excess gap. Use supplied shims that equal (or are as close as possible to) the excess gap value and place them on top of the bearing.

Note:

The distance between the outer race of the bearing and the upper end bell should not be less than 0.655 cm (0.262 in.). If it is, check for shims left in the bottom end bell and remove, if present.

c. Install the supplied motor preload spring washer (PN 62811), on top of the bearing (or the shims, if used).

6. Install the drive coupling. (see motor coupling replacement procedure, steps 5-6).

7. Reinstall tachometer optical disc with locking nut.

8. Reinstall dust cover on bottom of motor.

9. Reassemble drive motor and gyro-action drive assemblies. (see the motor replacement procedure step 10).

10. Install a new pair of carbon contact brushes.

11. Reinstall the drive motor and gyro-action drive assembly in the centrifuge, (see motor replacement procedure step 11).

IMBALANCE DETECTOR REPLACEMENT:

This procedure is to be used on RC-5C, RC-5C Plus, & RC-5C Plus brushless centrifuges.

1. Remove the imbalance detector as follows:

   a. Remove the drive motor and gyro-action drive assembly and separate the drive motor from the gyro-action drive. See the motor replacement procedure.
   b. Remove the screw which, secures the imbalance detector plug to the top of the gyro and unplug the harness.
   c. Remove the 3 nuts which secure the upper and lower plates of the gyro.
   d. Pull off upper plate and remove imbalance detector.

Note:
Observe position of imbalance detector harness before removal.

2. Install new imbalance detector as follows. Ensure that it is seated in recesses of upper and lower plates.

   a. Reseat upper plate and replace 3 nuts.
   b. Tighten screw to secure imbalance detector plug on top of gyro.

3. Reinstall drive motor and gyro-action drive assembly. See the motor replacement procedure, step 11.

4. Calibrate the imbalance detector per the calibration procedure found in the RC-5C Plus Service Manual.

GYRO BEARING HOUSING REPLACEMENT:

This procedure is to be used on RC-5C, RC-5C Plus, & RC-5C Plus brushless centrifuges.

1. Remove the imbalance detector. See imbalance detector replacement procedure, step 1.

2. Loosen the set screw in the centering cap and raise the cap on the shaft to permit access to the top retaining ring. Remove the ring using right angle, retaining ring pliers.

3. Pull the shaft assembly out of the bearing housing, using the tapered spindle as a handle. Remove any shims found in the bottom of the housing.

4. Remove the set screw that secures bearing housing to the mounting plate and is located on the side of the upper mounting plate.

5. Pushing from the bottom, remove bearing housing from upper mounting plate.

6. Lubricate rubber portion of new bearing housing with talcum powder and insert new bearing housing into upper mounting plate. Bearing housing is set on retaining ring in bottom of mounting plate.

7. Put a drop of Locktite #222 sealant on set screw and reinstall screw. Tighten set screw until it bottoms on bearing housing assembly: then back off set screw one full turn.

Note:
The set screw must not ground to any portion of bearing housing.

8. Reinstall any shims that have been removed.

9. Reinsert spindle assembly into bearing housing and secure with retaining ring.

10. Replace drive motor and gyro-action drive assembly.

CARBON BRUSH REPLACEMENT:

This procedure is to be used on RC-5C & RC-5C Plus centrifuges that use brush type motors.

To eliminate periodic motor brush inspection, a built-in warning system indicates when the brushes have worn to minimum operating length, when the BRUSHES advisory message lights, the brushes have approximately 8 hours of operational life remaining.

1. Remove drive motor and gyro-action drive assemblies. See motor replacement procedure, steps 1-7.

2. Remove the brushes. Figure 11-8, as follows:

   a. Loosen screw securing brush wire terminal.
   b. Retract and stow minor brush spring in brush spring stow groove.
   c. Lift the major brush spring and remove the brush from the holder with the wire attached.

3. Inspect the brushes and commutator as follows:

   a. If either brush is less than 14 mm (9/16 inch) as shown in Figure 11-8, badly pitted or unevenly worn, both brushes must be replaced.
   b. If the commutator is badly grooved, the armature may have to be replaced. See the armature replacement procedure.

4. Lift the major brush spring and insert new brush into the holder so that the beveled brush end matches the curvature of the commutator. Figure 11-8.

5. Route the brush wire. Figure 11-8, and secure with terminal screw as follows:

   a. Release the minor brush spring from its stowed position. Make sure that each spring is released into its respective channel free of binding.
   b. Proper tension of the major brush spring is 500 to 600 g (18 to 22 oz.) measured at the knee of the spring. Figure 11-8. Proper tension of the minor brush spring is 2 oz. measured at the knee of the spring. Figure 11-8.

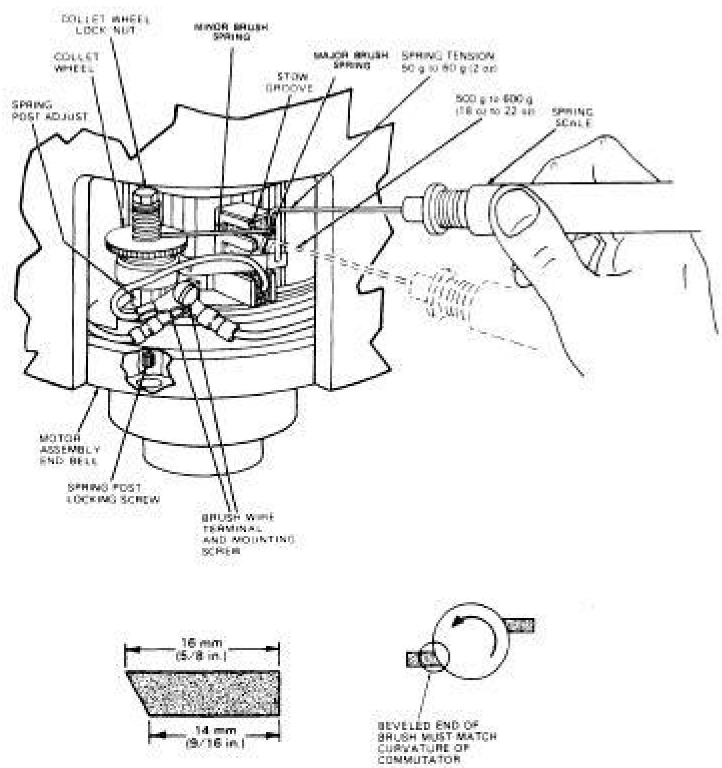


Figure 11-8. Carbon Brushes Replacement

6. Adjust major brush spring tension as follows:

    a. Proper tension is obtained by loosening the spring post with a 3/32 inch hex head Alien wrench through the access opening in the bottom of the end bell and turning the spring post with a 1/4 inch open end wrench.
    b. Secure the spring post when proper spring tension is obtained, then recheck tension. Readjust, if necessary.

7. Adjust minor brush spring tension as follows:

    a. Loosen locking bolt on end of spring post and rotate knurled wheel to adjust spring tension.
    b. Secure locking bolt on end of spring post, recheck tension and adjust if necessary.

8. Reinstall drive motor and gyro-action drive assembly. See motor replacement procedure, step 11.

9. Using the lightest rotor available, seat the new brushes by running the centrifuge at approximately 5000 rpm for approximately one hour.

TACHOMETER PRINTED CIRCUIT BOARD REPLACEMENT:

This procedure is to be used on RC-5C, RC-5C Plus, & RC-5C Plus brushless centrifuges.

1. Remove drive motor and gyro-action drive assemblies. See motor replacement procedure, steps 1-7.

2. Remove the Tachometer Board as follows:

   a. Remove the dust cover from the bottom of the motor.
   b. Disconnect Molex plug P/J 30 for Tachometer Board assembly.
   c. Remove 2 screws securing Tachometer Board to mounting plate.

Note:

On newer RC-5C Plus and RC-5C Plus Brushless centrifuges the motor will have 2 tachometer assemblies. Both tachometers are identical and are interchangeable.

3. Obtain and install new Tachometer Board as follows:

   a. Mount board on plate with two screws.
   b. Align Tachometer Board so that tach gear does not hit optical pickup when armature is moved in the housing.
   c. Reconnect Molex plug for Tachometer Board assembly.
   d. Reinstall the dust cover.

4. Reinstall drive motor and gyro-action drive assembly.

5. Reinstall front cabinet panel.

CONDENSER FAN REPLACEMENT:

This procedure is to be used on RC-5C, RC-5C Plus, & RC-5C Plus brushless centrifuges.

Warning:

The start and run capacitors in centrifuge retain high voltage charges. Be sure they are completely discharged before performing maintenance in that area. Discharge the start and run capacitors by shorting both terminals of the capacitor through a load resistor.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the mains power supply.

3. Remove the rear cabinet panel.

4. Remove constant current brake assembly. Figure 11-9.

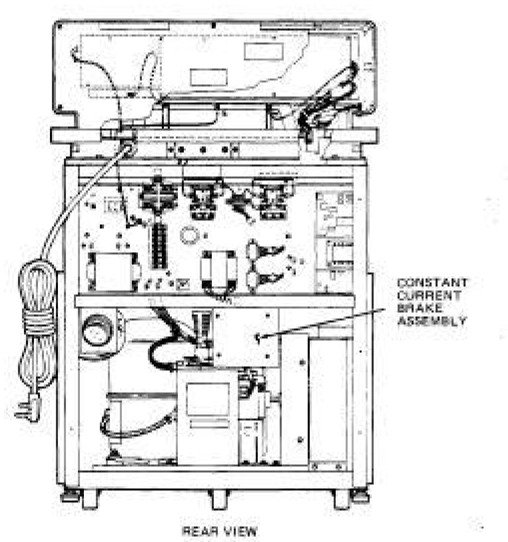


Figure 11-9. Location of Constant Current Brake Assembly

Note:

Figure #11-9 depicts a RC-5C centrifuge. The actual location of components may be different from the figure but the procedure remains basically the same. In the RC-5C Plus and RC-5C+ Brushless centrifuges the brake assembly is located in the front left corner of the centrifuge in the RC-5C Plus and on the centrifuge floor on the RC 5C Plus Brushless centrifuges.

5. Remove the condenser fan as follows:

    a. Remove the four bolts securing the fan motor and bracket to the condensing assembly deck.
    b. Move the motor and bracket away from the evaporator fins.
    c. Mark orientation of fan on the motor shaft.
    d. Loosen the set screw on fan and remove fan from motor shaft.

6. Vacuum accumulated dust from the evaporator fins.

7. Obtain and install new fan as follows:

    a. If a used fan is to be installed, check the blades and adjust them in accordance with Figure 11-10.
    b. Orient the fan on the motor shaft (see step 5c) and secure the fan by tightening the set screw on the flat surface of the motor shaft.
    c. Secure the motor bracket to the condenser assembly deck with 4 bolts.

8. On RC-5C centrifuges reinstall the constant current brake assembly.

9. Reinstall the rear cabinet panel.

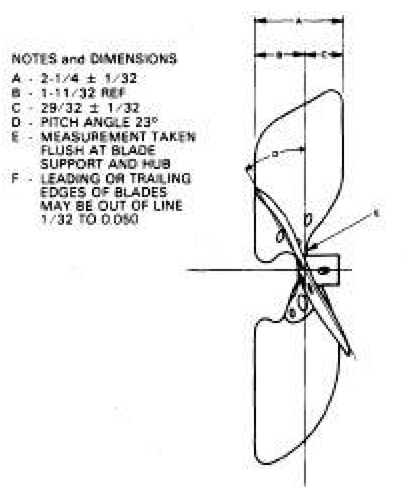


Figure 11-10. Condenser Fan

CONDENSER FAN MOTOR REPLACEMENT:

This procedure is to be used on RC-5C, RC-5C Plus, & RC-5C Plus brushless centrifuges.

Warning:

The start and run capacitors in centrifuge retain high voltage charges. Be sure they are completely discharged before performing maintenance in that area. Discharge the start and run capacitors by shorting both terminals of the capacitor through a load resistor.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the power supply.

3. Remove the rear cabinet panel.

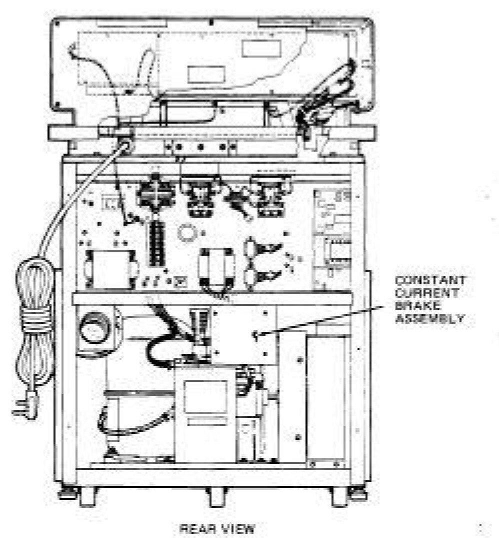


Figure 11-9. Location of Constant Current Brake Assembly

Note:

Figure #11-9 depicts a RC-5C centrifuge. The actual location of components may be different from the figure but the procedure remains basically the same. In the RC-5C Plus and RC-5C+ Brushless centrifuges the brake assembly is located in the front left corner of the centrifuge in the RC-5C Plus and on the centrifuge floor on the RC 5C Plus Brushless centrifuges.

4. Remove the constant current brake assembly. Figure 11-9.

5. On RC-5C centrifuges remove the capacitor box cover.

6. On RC-5C centrifuges remove the connector that secures the conduit from the fan motor to the capacitor box.

7. Disconnect the fan motor wires from the capacitor assembly then on RC-5C centrifuges remove the armor cable wires from the capacitor box.

8. Remove the condenser fan motor as follows:

   a. Remove the 4 bolts securing the fan motor and bracket to the condensing assembly / centrifuge deck.
   b. Move the motor and bracket away from the condenser cooling fins.
   c. Mark fan orientation on motor shaft. Loosen set screw and remove fan.
   d. Lift out the fan motor and bracket.
   e. On RC-5C centrifuges Remove the armor connector and conduit from the motor. Retain the armor covering, elbow and fittings, and red insulating inserts at each end of the conduit for reuse during motor installation.
   f. Remove the 2 screws securing the motor to the motor bracket.

9. Vacuum accumulated dust from the condenser fins.

10. Obtain and install new condenser fan motor as follows:

    a. Secure the motor to the bracket with the two screws and lock washers.
    b. On RC-5C centrifuges slide the conduit, elbow, and fittings over the motor wires. Secure the connector to the motor.
    c. Orient the fan on the motor shaft as marked in step 8c. Secure the fan on the shaft with the set screw.
    d. Place the motor and bracket in the approximate position on the condensing assembly / centrifuge deck.
    e. Secure the motor bracket on the condensing assembly deck with bolts.

11. On RC-5C centrifuges insert the red insulator into the end of the conduit.

12. Reconnect the condenser fan wires to the capacitor box / capacitor assembly.

13. On RC-5C centrifuges secure the conduit to the capacitor box.

14. On RC-5C centrifuges reinstall the capacitor box cover.

15. Reinstall constant current brake assembly.

16. Reinstall the rear cabinet panel.

EVAPORATOR REPLACEMENT:

This procedure is to be used on RC-5C, RC-5C Plus, & RC-5C Plus brushless centrifuges.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the mains power supply.

3. Remove all four cabinet panels.

4. Remove the four 9/16 inch bolts (underneath top deck) which secure the front console assembly and top deck to the centrifuge frame. Note the locations of any shims that are used between the top deck and the mounting bracket.

5. Disconnect all wiring to the front control panel and top deck so that the console and the deck can be removed from centrifuge frame as follows:

   a. Remove four screws, which secure front control panel to console.
   b. Remove the front control panel and rest it on the top deck.
   c. Disconnect P/J 2,3, and 4 from Microcomputer Board.
   d. Disconnect P/J 33 from Switches and Indicators Board.
   e. Disconnect all wiring from the front control panel to the console. (Portach and 2 ground straps).
   f. Push all wiring down through access holes in top deck.
   g. Reinstall front control panel with two screws.

6. Remove the entire top deck and console from the centrifuge.

Note:

Remove any shims between the top deck and the mounting bracket.

7. Using the door lock override button, open the centrifuge chamber door.

8. Remove solenoid release arm from centrifuge. Figure 11-11, as follows:

   a. Remove shoulder screw from solenoid release arm using a 5/32 inch Allen wrench. Unhook return spring from cotter pin on frame.
   b. Remove solenoid release arm and spring from centrifuge.

9. Remove wooden deck as follows:

   a. Remove 4 bolts holding down wooden deck using 9/16 inch socket wrench.

b. Pull up and remove top wooden deck complete with plastic ring and urethane seal.

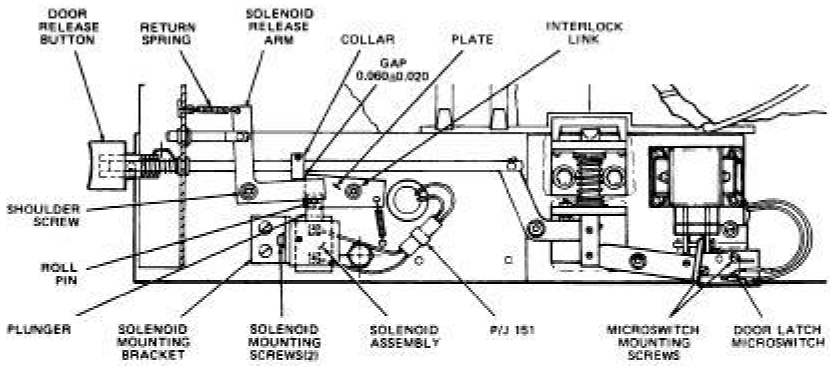


Figure 11-11. Door Latch Assembly

10. Pivot the upper retaining plates. Figure 11-12, as follows:

    a. Scribe alignment marks on the frame at the front, side, and rear of the retaining plates.
    b. Remove the 3 bolts at the rear of each retaining plate.
    c. Loosen the front retaining bolt so that the plate can be pivoted out of the way of the liner.
    d. Pu11 the three wire harnesses (two on right, one on left) down through the plates and pivot plates clear of liner.

11. Remove the air and floor temperature sensors from the evaporator.

12. Remove the drive motor and gyro-action drive assemblies. See the motor replacement procedure.

13. Remove the imbalance detector harness from the liner.

14. Remove the refrigerant from the system.

Note:

Follow the procedure for refrigerant recovery outlined in the Sorvall® Refrigeration Service Guide. Insure that the refrigerant recovery and disposal follows **ALL** local regulations and practices.

Warning:

NEVER vent refrigerant into the atmosphere. Follow **ALL** local regulations and standard practices for refrigerant recovery and disposal.

15. Disconnect and separate the refrigeration fittings leading to the evaporator, Figures 11-13 and 11-14.

Caution:

Use flare nut wrenches only to tighten and loosen refrigeration fittings. Use of other wrenches can destroy fittings and cause leakage of refrigerant.

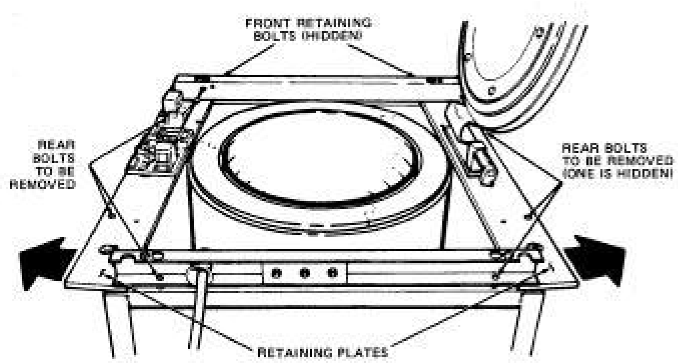


Figure 11-12. Upper Retaining Plates

Note:

Figures #11-12, 11-13. & 11-14 depict a RC-5C centrifuge. The actual location of components in RC-5C Plus & RC-5C Plus Brushless centrifuges may be different from the figures but the procedure remains basically the same.

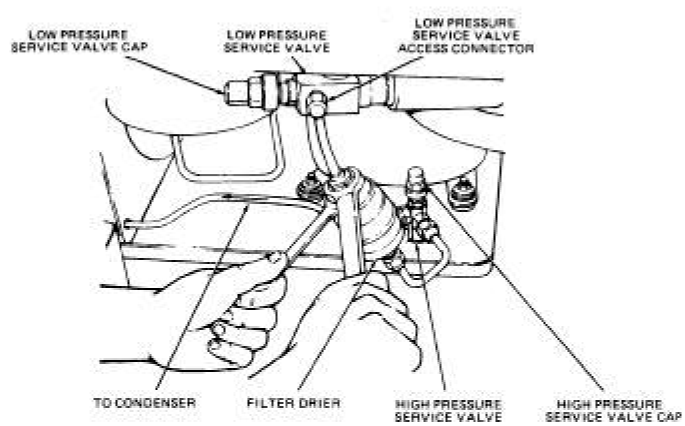


Figure 11-13. Disconnect and Separate High Pressure Refrigeration Lines

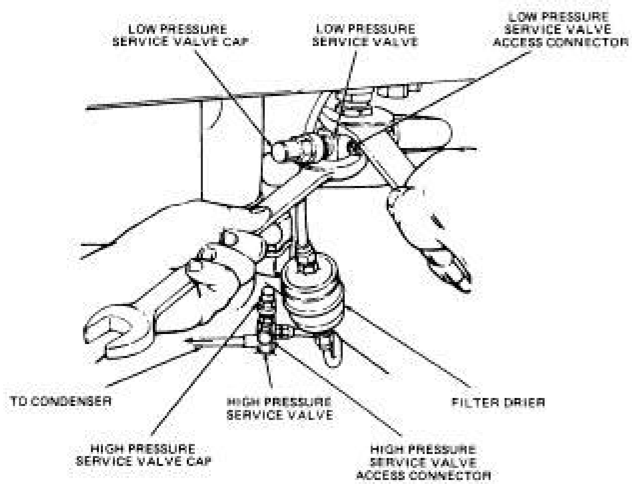


Figure 11-14. Disconnect and Separate Low Pressure Refrigeration Lines

16. Remove the evaporator as follows:

    a. Using two large screw drivers, pry the evaporator liner and lock foam insulating material up from the guard ring until it breaks loose, Figure 11-15.
    b. Grasp the evaporator at the inner bottom rim and pull it out of the chamber.

17. Obtain and install new evaporator assembly as follows:

    a. Lower the new evaporator into the guard ring.
    b. Connect the refrigeration lines.

    Note:
    Insure to use new Teflon seals whenever making refrigeration connections.

Note:
Use Loctite Leak Lock sealant (or other compatable sealant) on all threaded refrigeration fittings

    c. Remove the adhesive backing and install the 3 pieces of urethane seal supplied in the kit on top of the lock foam insulating material, Figure 11-16.

18. Reinstall the upper retaining plates as follows:

    a. Pivot the retaining plates to their original positions using the alignment marks made in step 10.

b. Secure the retaining plates with the 8 mounting bolts.
c. Push the three harnesses up through the retaining plates and reconnect them to the door switches. One harness, P33, remains disconnected.

19. Open and close door to check for binding at door interlock. Adjust as necessary.

20. Place wooden deck with plastic ring and rubber seal on the evaporator liner. Adjust wooden deck so door interlock is centered in indentation in plastic ring.

21. Secure the wooden deck with the four mounting bolts.

22. Reinstall the manual door release rod linkage. Figure 11-11. Apply a drop of lubricating oil to shoulder screw before tightening.

23. Press solenoid plunger to ensure pivot plate clears collar. Adjust so the gap between plate and the collar is 0.060 ± 0.020 inches. Figure 11-11.

24. Replace the entire top deck and console on the centrifuge. Do not install bolts.

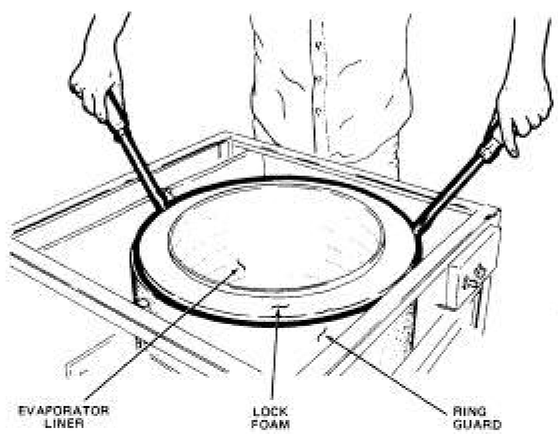


Figure 11-15. Pry Evaporator from Guard Ring

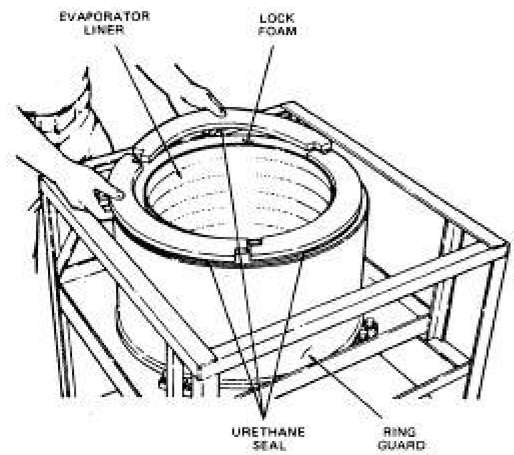


Figure 11-16. Install Urethane Seal

24. Reconnect all wiring to front console panel and deck as follows:

    a. Remove front control panel.
    b. Reconnect P/J 2, 3, and 4 to Microcomputer Board.
    c. Reconnect P/<3 33 to Switches and Indicators Board.
    d. Reconnect all other wiring: Portach and 2 ground straps.
    e. Reinstall front control panel.

Note:
When securing ground wires, be sure to install star washer between ring terminal and chassis.

25. Reinstall any shims that have been removed.

26. Reinstall and tighten four bolts of top deck. Adjust top deck so door does not bind at hinge when opened.

27. Reinstall and reconnect the air and floor temperature detectors.

28. Reinstall drive motor and gyro-action drive assemblies. See motor replacement procedure.

29. Recharge the refrigeration system and check for leaks

Note:
Charge the refrigeration system following the procedures that are outlined in the Sorvall® Refrigeration Service Guide.

30. Reinstall all four cabinet panels.

CONDENSING ASSEMBLY REPLACEMENT:

This procedure is to be used on RC-5C centrifuge.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the mains power supply.

3. Remove all four cabinet panels.

4. Remove constant current brake assembly and the motor exhaust duct.

5. Remove the capacitor box cover.

6. Disconnect the three wires which enter the right side of the capacitor box through the blue strain relief.

7. Press the locking tabs on the blue strain relief and remove the strain relief and wire harness from the capacitor box.

8. Remove the Constant Current Brake Assembly and the Motor Exhaust Duct from the instrument.

9. Remove the refrigerant from the system.

Note:

Follow the procedure for refrigerant recovery outlined in the Sorvall® Refrigeration Service Guide. Insure that the refrigerant recovery and disposal follows **ALL** local regulations and practices.

Warning:

NEVER vent refrigerant into the atmosphere. Follow **ALL** local regulations and standard practices for refrigerant recovery and disposal.

10. Remove the condensing assembly as follows:

    a. Disconnect the suction line from the compressor using an open end wrench (1-3/8 inch). Figure 11-17.

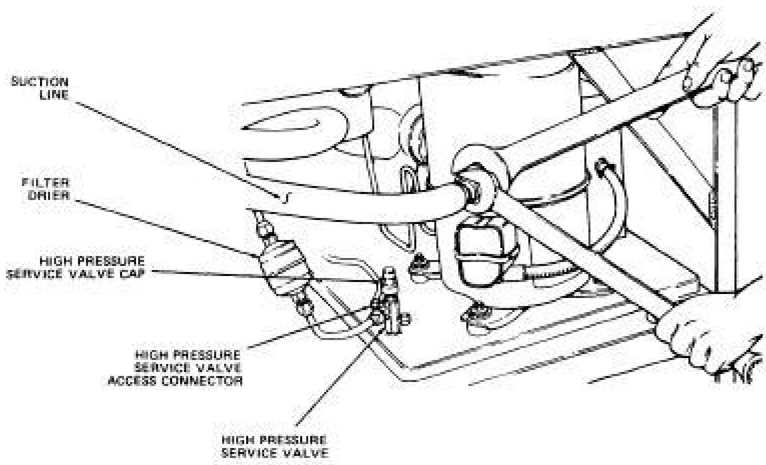


Figure 11-17. Disconnect Suction Line from Compressor

b. Disconnect the high pressure line from the service valve using a flare nut wrench (25/32 inch). Figure 11-18.
c. Remove the three socket head screws securing the refrigeration assembly base to the centrifuge frame using a 1/4 inch Alien wrench.
d. Pull the condenser assembly toward the rear of the centrifuge and remove it from the centrifuge.

11. Obtain and install the condensing assembly as follows:

a. Place the new condenser (on the shipping skid) behind the instrument with the condenser fins facing the left side of the instrument. After removing the 1” x 1” wood rail from the shipping skid (closest to the instrument), slide the condenser directly into the instrument from the skid. Care needed to be taken so that the wires coming from the Lower Control Panel are not pinched. The condenser plate should be located 2 3/8” from the right side of the instrument frame and 1 3/8” from the left side of the instrument frame. See Figures #1 & #2. Loosely engage the socket head screws that secure the condensing assembly to the instrument frame,

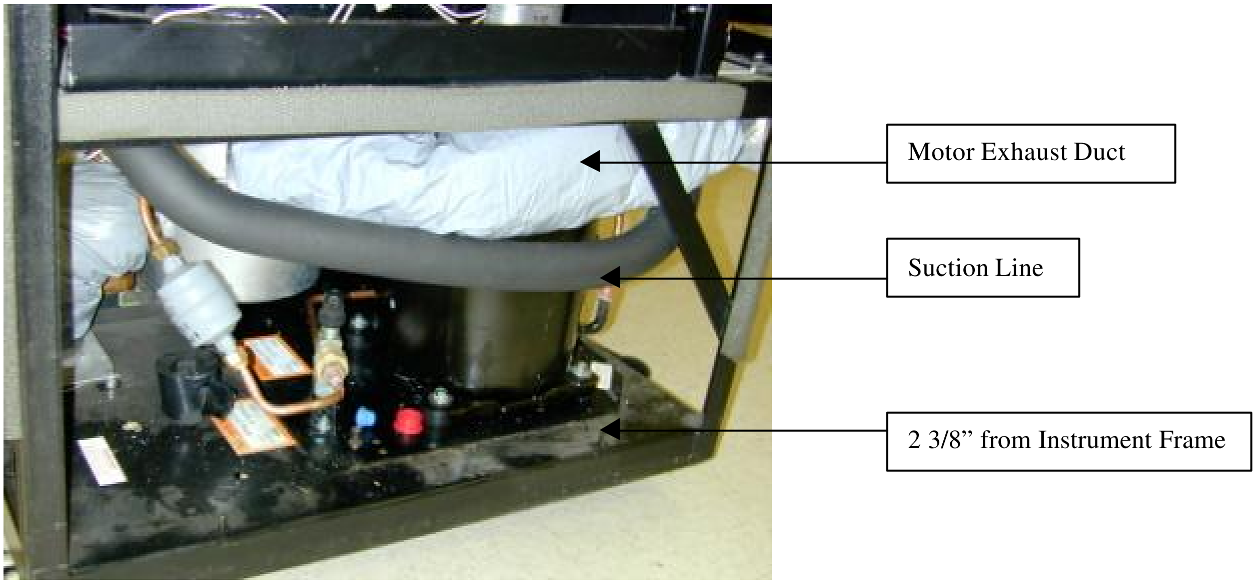


Figure #1 (Instrument Right Side)

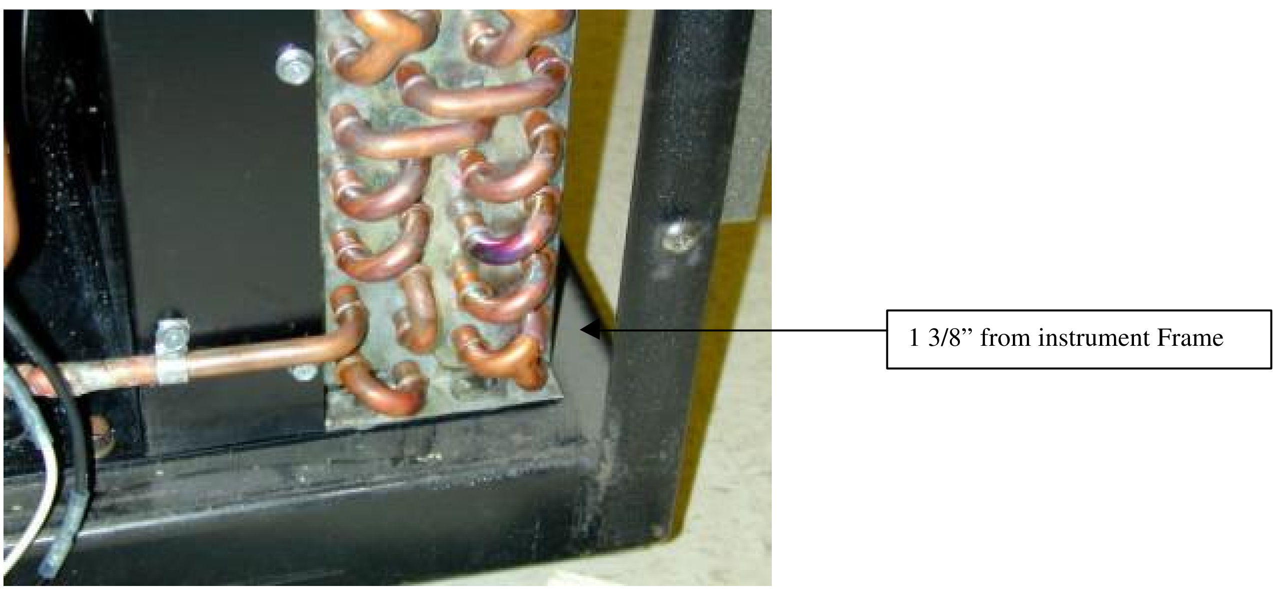


Figure #2 (Instrument Left Rear Corner)

Note:

The suction line that is supplied with the kit appears straight but is constructed of a corrugated tube which is easily bent into the shape that is required without the use of any tools. The Suction line needs to be pre-formed prior to installation into the instrument.

b. Reconnect the high pressure line and the suction line to the refrigeration assembly.

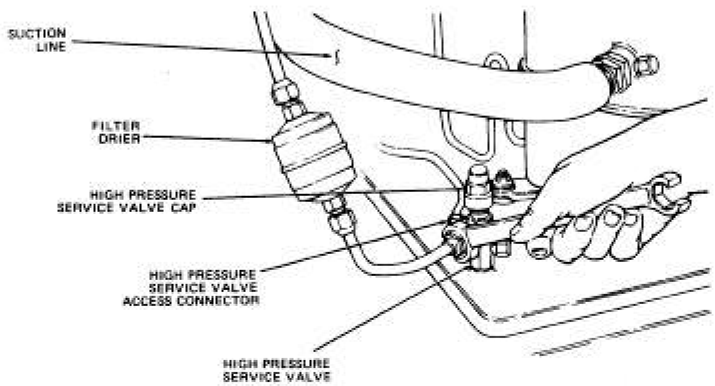


Figure 11-18. Disconnect High Pressure Line from Service Valve

Caution:

Use flare nut wrenches only to tighten and loosen refrigeration fittings. Use of other wrenches can destroy fittings and cause leakage of refrigerant.

Note:

Ensure Teflon seal is in place at the compressor inlet before connecting the suction line.

Note:

Apply a drop of refrigerant oil to the front and back of all flare fittings before assembly.

12. After pre-forming the Suction Line (P/N 20262 supplied with the 12139 Kit or P/N 50362 supplied with the 20802 kit). Install the new Teflon Seals onto the Compressor and the Evaporator, and then attach the Suction Line loosely (Service Valve to the Compressor) at either end. After both ends are started tighten both ends. The suction line should be routed as depicted in figures #1 & #3. The Service valve should sit at an approximate 45° angle insuring that enough room to install the cap over the valve stem. Use Leak-Loc sealant on all threaded refrigeration connections.

Figure #3 Suction line orientation

13. Connect the wires to the capacitor box and install the blue strain relief.

14. Transfer the MOV that is connected between terminals #4 & #5 on the potential relay on the assembly that was removed from the instrument to the same locations on the new potential relay.

15. Transfer the MOV that is connected between terminals #10 & #12 on the terminal block on the old condensing assembly to the same locations on the new condensing assembly.

16. Install the capacitor box cover.

17. Reinstall the constant current brake assembly.

18. Recharge the refrigeration system and check for leaks

Note:
Charge the refrigeration system following the procedures that are outlined in the Sorvall® Refrigeration Service Guide.

19. Replace all four cabinet panels.

RC-5C *Plus* Service Manual
Repair & Replacement Procedures

Compressor Kit RC-5C *PLUS* Centrifuges.
(for use in 1999 instruments and older with serial numbers 9901492 and below)

1. Disconnect the main power by turning OFF the main circuit breaker on the instrument to be repaired and disconnect the power cord from the power.

2. Remove all of the panels from the instrument.

3. Remove and recover the refrigerant in the instrument observing all local laws for refrigerant recovery.

Note:
Follow the procedure for refrigerant recovery outlined in the Sorvall® Refrigeration Service Guide. Insure that the refrigerant recovery and disposal follows **ALL** local regulations and practices.

Warning:
NEVER vent refrigerant into the atmosphere. Follow **ALL** local regulations and standard practices for refrigerant recovery and disposal.

4. Remove and discard the run capacitor, start capacitor, and potential relay.

5. Disconnect the suction line from the evaporator and the existing compressor assembly. Remove the suction line and discard.

6. Disconnect and discard the filter drier from the evaporator and the high side service valve.

7. Seal the open evaporator lines to protect the system from moisture.

8. Remove the faulty compressor and discard, making sure that all local laws are followed regarding disposal of the assembly.

9. Install the new compressor assembly, PN 77375 into the instrument and secure it to the instrument frame.

10. Install the tube assembly, PN 74348, supplied with the kit, to the discharge port on the compressor and the upper fitting on the condenser. Install the Teflon seals and use leak-lock sealant, PN 92294 on all refrigeration connections.

11. Install the filter drier, PN 74346, supplied with the kit, to the evaporator and the high side service valve of the condenser. Install the Teflon seals and use leak lock sealant, PN 92294 on all refrigeration connections.

12. Install the new suction line, PN 74347 with the to the suction port on the compressor and to the evaporator. Install the Teflon seals and use leak lock sealant, PN 92294 on all refrigeration connections.

13. Using a vacuum pump evacuate the system.

14. While evacuating the system install the new compressor start capacitor, PN 92734, run capacitor, PN 92733, and potential relay, PN 92732. Wire the assembly that is shown in figure 1.

15. Attach a thermocouple probe to the suction line 6 to 8 inches from the compressor. Insure that the probe is secured tightly on the copper pipe and insulated under the pipe insulation.

16. After evacuation is complete charge the system with 1.75Ibs. of HP-62 refrigerant through the high side service valve. After charging the condenser check for leaks using a calibrated leak detector.

WARNING:

DO NOT start centrifuge without refrigerant.

17. Level the instrument and install a rotor that will create the highest heat load. Perform a pre-cool run with the temperature set at the lowest possible setting. When the displayed temperature reaches approximately 5°C increase the instrument speed to the rotor's maximum speed.

18. Allow approximately 10 minutes to make sure that the high heat load condition has stabilized.

19. Calculate the superheat by subtracting the evaporator temperature obtained from the low side gauge on the charging manifold from the temperature obtained from the thermocouple placed on the suction line installed in step 15. The superheat value should be 30°F ±2°F. Adjust the charge of refrigerant by adding or removing refrigerant until the superheat is within specification.

CAUTION:

Any addition or removal of HP-62 refrigerant must be completed in liquid form. Failure to do so will result in refrigerant fractionating and adversely effect the instrument's performance.

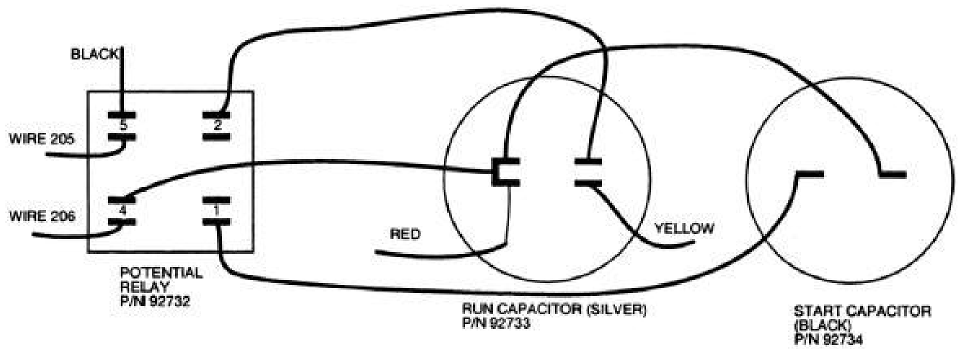
20. Calculate the system T.D. by taking the difference between the ambient air temperature and the condenser temperature obtained from the high side gauge on the charging manifold. The T.D. should be 25°C maximum.

21. Close both service valves and remove the charging manifold.

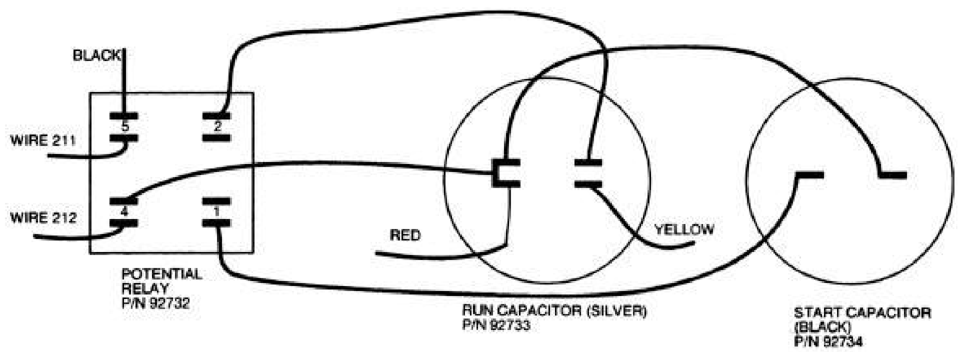
22. Install all caps on the service valves and insulate the low side service valve using the supplied cork insulating tape and foam insulating tape.

23. Re-install the panels back on the instrument.

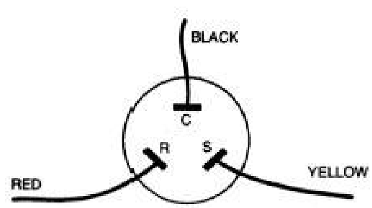
RC-5C+ COMPRESSOR WIRING



RC-5B+ COMPRESSOR WIRING



COMPRESSOR TERMINAL WIRING



RC-5C *Plus* Service Manual

Repair & Replacement Procedures

AIR TEMPERATURE SENSOR REPLACEMENT

This procedure is to used on RC-5C, RC-5C *Plus*, and RC-5C *Plus* Brushless centrifuges.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the power supply.

3. Remove the front cabinet panel.

4. Using the door lock override button, open the centrifuge chamber door.

5. Remove air temperature sensor as follows:

   a. Disconnect Molex plug for air temperature sensor, P/J 110.
   b. Remove red and black wires from J110 using a Molex pin extractor tool.
   c. Remove and save thermal insulating putty from hole in bottom of frame through which the air temperature sensor wires pass.
   d. Pry out air temperature sensor from the evaporator. Figure 11-22.
   e. Remove any excess putty from the hole by pushing it out through the bottom of the chamber with a screwdriver.

6. Calibrate the temperature control circuit of the Microcomputer Board, (see calibration section of manual).

7. Disconnect the sensor from the harness and remove from the ice bath.

8. Install the new air temperature sensor as follows:

   a. Insert the wires of the new sensor through the hole in the evaporator. Using a screwdriver, seat the sensor in mounting hole.
   b. Insert red and black wires into J110 maintaining original orientation.
   c. Reconnect P/J 110.
   d. Apply thermal insulating putty to hole in bottom of frame where air temperature sensor wires pass through.

Caution:

Do not use excessive force when seating air temperature sensor.

9. Reinstall the front cabinet panel.

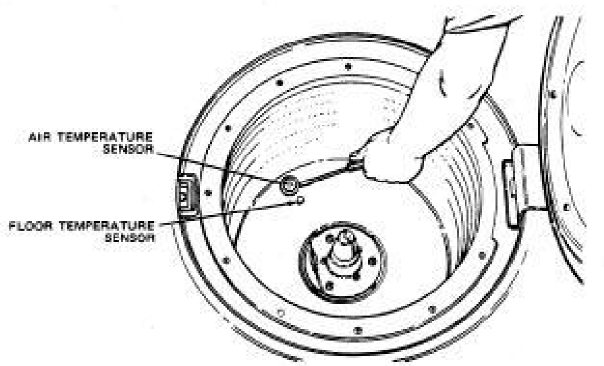


Figure 11-22. Location of Air and Floor Temperature Sensors

RC-5C *Plus* Service Manual

Repair & Replacement Procedures

FLOOR TEMPERATURE SENSOR REPLACEMENT

This procedure is to used on RC-5C, RC-5C *Plus*, and RC-5C *Plus* Brushless centrifuges.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the mains power supply.

3. Remove the front cabinet panel.

4. Using the door lock override button, open the centrifuge chamber door.

5. Remove floor temperature sensor as follows:

    a. Disconnect Molex plug for floor temperature sensor P/J 109.
    b. Remove red and black wires from J 109.
    c. Remove and save thermal insulating putty from hole in bottom of frame through which the floor temperature sensor wires pass.
    d. Unscrew the floor temperature sensor using a 9/16 inch socket wrench and remove it from the evaporator. Figure 11-22.
    e. Remove any excess putty from the hole by pushing it out through the bottom of the chamber with a screwdriver.

6. Install new floor temperature sensor as follows:

    a. Insert the wires of the new sensor through the hole in the evaporator.
    b. Screw in new floor temperature sensor.

CAUTION:

Do not over tighten floor temperature sensor.

    c. Insert red and black wires into J109.
    d. Reconnect P/J 109.
    e. Apply thermal insulating putty to hole in bottom of frame where floor temperature sensor wires pass through.

7. Reinstall the front cabinet panel.

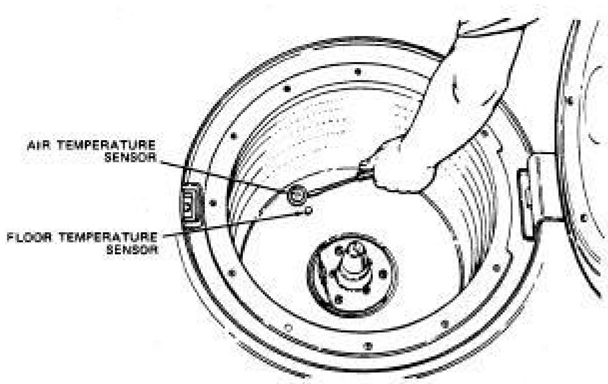


Figure 11-22. Location of Air and Floor Temperature Sensors

CURRENT SENSING TRANSFORMER (T103) REPLACEMENT

This procedure is to used on RC-5C, RC-5C *Plus* centrifuges that use brush type motors.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the mains power supply.

3. Remove the rear cabinet panel.

4. Remove the current limiting transformer as follows:

    a. Disconnect Molex plug P/J 112.
    b. Disconnect harness wires to K102 and K103.
    c. Remove 2 screws, which mount the transformer to the relay panel and lift out transformer.

5. Obtain and install new transformer as follows:

    a. Mount transformer on relay panel with 2 screws.
    b. Reconnect harness wires to K102 and K103, and reconnect Molex plug P/J 112.

6. Calibrate the current limiting circuit for the motor. Paragraph 12-2.a.

7. Reinstall the rear cabinet panel.

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Repair & Replacement Procedures

DOOR LATCH MICROSWITCH (S102) REPLACEMENT

This procedure is to used on RC-5C, RC-5C *Plus*, RC-5C *Plus* Brushless centrifuges.

1. Set the main circuit breaker, POWER switch, to OFF.
2. Disconnect the power cord from the mains power supply.
3. Remove the front and right cabinet panels.
4. Remove the two mounting screws for the latch microswitch using a 90° offset screwdriver. Figure 11-24.
5. Disconnect the wires to the microswitch and remove the switch.
6. Obtain and install new door latch microswitch as follows:
   a. Attach switch to mounting bracket with screws using a 90° offset screwdriver.
   b. Reconnect all wires to the microswitch.

NOTE:

No adjustment is necessary unless mounting bracket for the switch was removed.

7. Reinstall front and right cabinet panels.

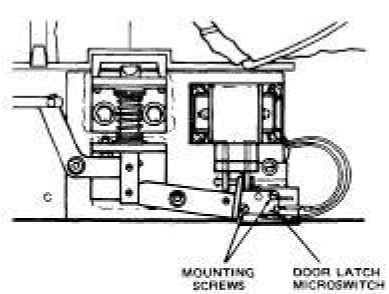

Figure 11-24. Door Latch Microswitch

Repair & Replacement Procedures

DOOR HINGE MICROSWITCH (S103) REPLACEMENT

This procedure is to used on RC-5C, RC-5C *Plus*, RC-5C *Plus* Brushless centrifuges.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the mains power supply.

3. Remove the left cabinet panel.

4. Disconnect the wires to the microswitch and open the chamber door.

5. Remove the locking nut for the door hinge microswitch using a 1/2 inch swivel socket and remove the switch. Figure 11-25.

6. -Obtain and install new door hinge microswitch as follows:

    a. Mount the new microswitch and tighten locking nut.

CAUTION:

Do not overtighten the locking nut.

    b. Reconnect all wires to the microswitch.

7. Reinstall left cabinet panel.

8. Connect the power cord to a power supply.

9. Set the main circuit breaker, POWER switch, to ON.

10. Set up the centrifuge as follows:

    a. Set SPEED RPM switches to 5000.
    b. Set TEMP RUN switches to 04°C.
    c. Install any rotor and set ROTOR CODE switches appropriately.
    d. Set the key switch to NORMAL.

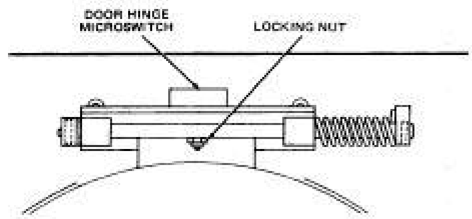

Figure 11-25. Door Hinge Microswitch

11. Open chamber door. Press START switch. start with chamber door open. The centrifuge should not start.

12. Close chamber door. Press START switch. The centrifuge should start normally.

13. Press the STOP switch.

RC-5C *Plus* Service Manual

Repair & Replacement Procedures

DOOR SOLENOID REPLACEMENT

This procedure is to used on RC-5C, RC-5C *Plus*, RC-5C *Plus* Brushless centrifuges.

1. Set main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the mains power supply.

3. Remove alt the cabinet panels.

4. Remove the top deck and console assembly by removing the mounting bolts for the top deck and propping up the deck to gain access to the door solenoid.

NOTE:

Do not stress the wire harnesses in the upper console assembly.

5. Remove the door solenoid as follows:

   a. Unplug the solenoid Molex connector P/J 151, Figure 11-26.

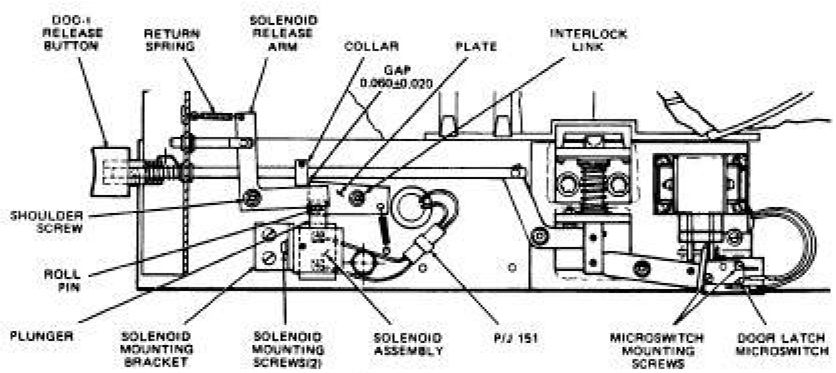

Figure 11-26. Door Solenoid

   b. Remove the two screws securing the solenoid to the mounting bracket using a 90° offset screwdriver.
   c. Remove the solenoid.

6. Obtain and install a new door solenoid as follows:

   a. Mount the solenoid to the mounting bracket with the two screws.
   b. Reconnect P/J 151.

NOTE:

Ensure that the protruding end of the roll pin on the solenoid plunger is facing up and contacts the solenoid release arm.

7. Reinstall or reseat the top deck and console assembly.

8. Reinstall alt cabinet panels.

9. Connect power cord to a power supply.

10. Set main circuit breaker, POWER switch, to ON.

11. Verify that the solenoid is energizing and that the door can be opened by pressing the DOOR button.

12. Set main power circuit breaker, POWER switch, to OFF.

13. Verify that the door can be opened using the manual release rod.

RC-5C *Plus* Service Manual

Repair & Replacement Procedures

SLOW START PRINTED CIRCUIT BOARD REPLACEMENT

This procedure is to used on RC-5C centrifuges.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the mains power supply.

3. Remove the front and left cabinet panels.

4. Remove the slow start assembly from centrifuge. Figure 11-27, as follows:

   a. Disconnect P/J 35 from slow start assembly, using the small locking tab on the bottom of P/J 35.
   b. Remove ground strap which connects slow start chassis to centrifuge frame.
   c. Remove 3 mounting screws of slow start assembly and remove assembly from centrifuge.

5. Remove Slow Start Board from assembly. Figure 11-27, as follows:

   a. Remove connectors El, E2, E3, E4, E5, and E7.
   b. Remove 4 screws mounting Slow Start Board to slow start assembly.

6. Obtain and install new Slow Start Board on assembly as follows:

   a. Place board in position and mount with the 4 screws.
   b. Reconnect E1, E2, E3, E4, E5, and E7.

7. Reinstall slow start assembly.

8. Reinstall front and left cabinet panels.

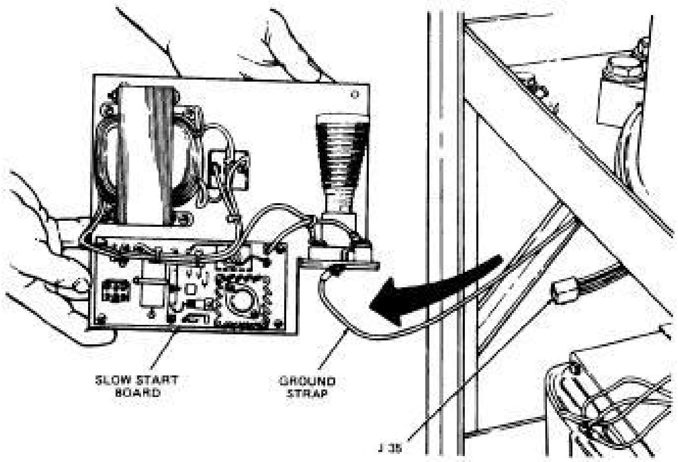

Figure 11-27. Remove Slow Start Board and Assembly

RC-5C *Plus* Service Manual

Repair & Replacement Procedures

HIGH VOLTAGE INTERFACE PRINTED CIRCUIT BOARD REPLACEMENT

This procedure is to be used on RC-5C, RC-5C *Plus*, centrifuges that use brush type motors.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the mains power supply.

3. Remove the left cabinet panel.

4. Remove High Voltage Interface Board from the centrifuge as follows:

   a. Disconnect ribbon connector P/J 32 from High Voltage Interface Board.
   b. Remove 4 screws which mount board to the mounting bracket.
   c. Unplug board from P/J 101.

5. Obtain and install new High Voltage Interface Board as follows:

   a. Insert board into P/J 101.
   b. Mount board to the mounting bracket with 4 screws.
   c. Reconnect ribbon connector P/J 32 to High Voltage Interface Board.

6. Check current limit calibration.

7. Reinstall left cabinet panel.

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Repair & Replacement Procedures

DRIVE INTERFACE PRINTED CIRCUIT BOARD REPLACEMENT

This procedure is to be used on RC-5C *Plus* Brushless centrifuges.

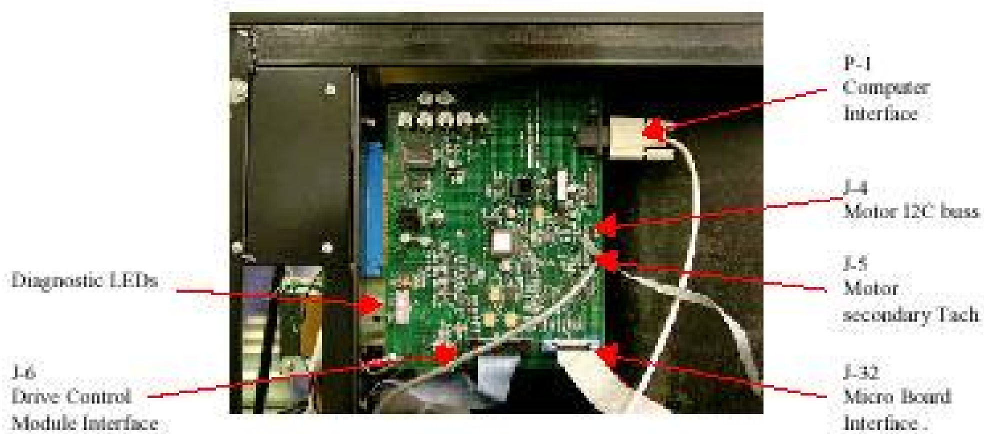
1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the mains power supply.

3. Remove the left cabinet panel.

4. Remove the Drive Interface Board from the centrifuge as follows:

   a. Disconnect connectors P/J 4, P/J 5, P/J 6, & P/J 32 from the Drive Interface Board.
   b. Remove 4 screws which mount board to the mounting bracket.
   c. Unplug board from P/J 101.



Drive Interface Printed Circuit Board

5. Obtain and install new Drive Interface Board as follows:

   a. Insert board into P/J 101.
   b. Mount board to the mounting bracket with 4 screws.
   c. Reconnect connectors P/J 4, P/J 5, P/J 6, & P/J 32 to the Drive Interface Board.

6. No Calibrations are necessary.

7. Reinstall left cabinet panel.

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Repair & Replacement Procedures

MICROCOMPUTER PRINTED CIRCUIT BOARD REPLACEMENT

This procedure is to be used on RC-5C, RC-5C *Plus*, and RC-5C *Plus* Brushless centrifuges.

1. Set the circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the power supply.

3. Remove the front control panel as follows:

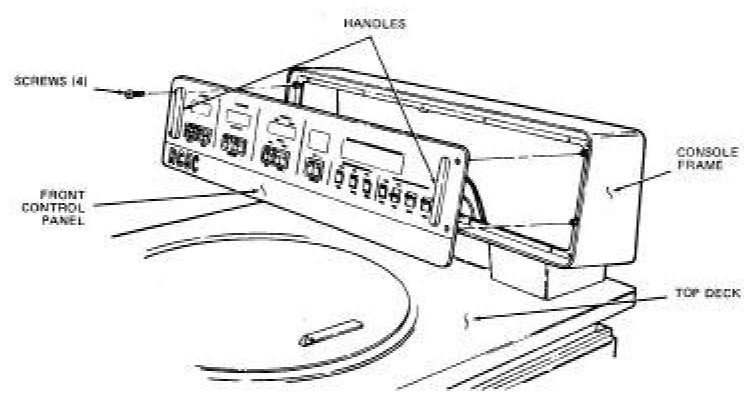
   a. Remove 4 screws, which mount front control panel to console frame.
   b. Position all lever wheel switches to 5; the middle position; or in the case of locked lever wheel switches, to the highest value allowable.

CAUTION:

To remove the Microcomputer Board on RC-5C centrifuges, the lever wheel switches must be set as indicated in step 3b. Failure to position the lever wheel switches as indicated can damage the switches and/or the Microcomputer Board.

   c. Grasp the handles and, using a straight horizontal motion, pull the front control panel out of the frame. Figure 11-28.
   d. Lower the panel onto the top deck and rest it on the handles.

4. Remove 4 screws from mounting posts at front of frame. Figure 11-28.



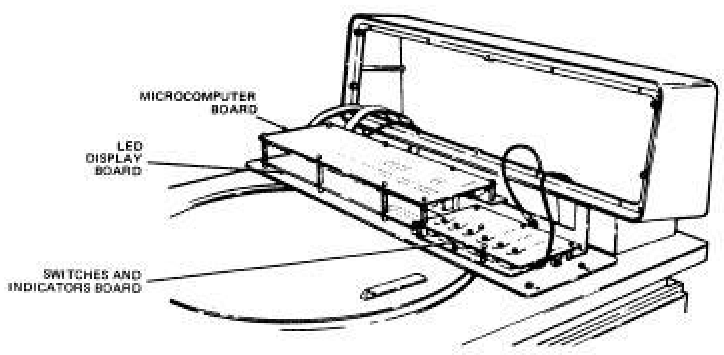


Figure 11-28. Remove Front Control Panel

5. On RC-5C centrifuges replace lever wheel switches, if necessary, as follows:

   a. Pivot the Microcomputer Board up on the hinge showing leverwheel switches and front of board. Figure 11-29.
   b. Remove the block of switches to be changed by pulling them straight out from the Microcomputer Board.
   c. Plug in leverwheel switch block. Support the back of the board while inserting switches.

CAUTION:

Support the back of the Microcomputer Board and do not use excessive pressure when inserting the new leverwheel switches. Excessive pressure can damage the Microcomputer Board and/or its circuitry.

   d. Position the new leverwheel switches as in step 3b.
   e. Pivot the Microcomputer Board back into the closed position.
   f. Go to step 7.e.

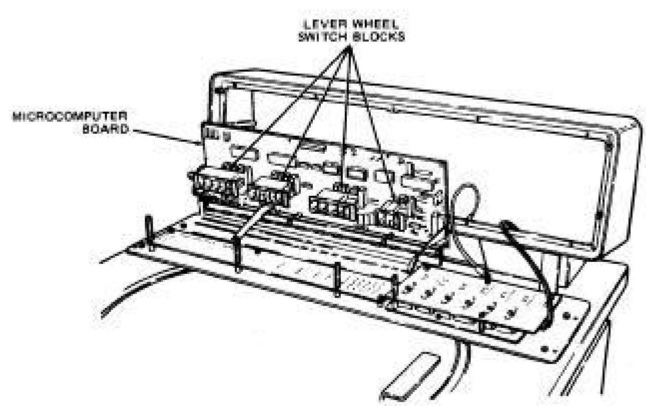


Figure 11-29. Microcomputer Board in Up Position

6. Remove the Microcomputer Board as follows:

    a. On RC-5C centrifuges remove the 4 nuts from mounting posts at hinge frame. Figure 11-28, and lift board off mounting posts.
    b. On RC-5C *Plus* centrifuges remove all of the board mounting hardware and lift the board from the mounting posts.
    c. Disconnect from the board ribbon connectors P/J 1, P/J 2, and P/J 21; and connectors P/J 3 and P/J 4.

7. Obtain and install new Microcomputer Board as follows:

    a. Install leverwheel switches, step 5.b-d.
    b. Reconnect all ribbon and other connectors.
    c. Seat board on mounting posts.

NOTE:
On RC-5C centrifuges do not pinch or chafe the ribbon cables when pivoting the Microcomputer Board.

    d. Reinstall 4 nuts to mounting posts at hinge frame.
    e. Reinstall 4 screws to mounting posts at front of frame.

8. Calibrate new Microcomputer Board.

9. Reinstall front control panel.

RC-5C *Plus*

Table of Contents

7.0 Calibration & Software

Section #7 Calibration

This section includes all of the necessary calibration procedures for the RC-5C, RC-5C *Plus*, and RC-5C *Plus* Brushless centrifuges.

Precautions for Handling Printed Circuit Boards

Caution:

Some printed circuit board components can be damaged by static voltage; therefore, it is important to use these precautions when handling printed circuit boards.

The printed circuit boards in this centrifuge consist of circuits that contain CMOS devices; as a result, they are especially susceptible to damage by electrostatic discharge (ESD). If you handle these boards, you must be familiar with generally accepted ESD handling procedures.

To avoid damaging static-sensitive electronic components, observe all of the following precautions when handling printed circuit boards and electronic components and assemblies:

- Wrap P.C. boards in a conductive plastic packing material, such as Velostat® by 3M Company, whenever they are shipped or stored.
- Always handle a printed circuit board by its corners only. Handle components by the cap edges or bodies.
- Cover all connectors with conductive plastic whenever a printed circuit board is out of the centrifuge.
- When handling unwrapped P.C. boards, electronic components, or electronic assemblies, use properly grounded electrostatic discharge protective devices (for example, wrist straps, heel straps, conductive mats).
- Place static-sensitive PC. boards, electronic components, or electronic assemblies on properly grounded work surfaces or in containers designed to dissipate static charge. Touch the work surface before touching the electronic components.
- Install static sensitive parts in the centrifuge or wrap them in protective packaging before removing your protective equipment.
- Keep the following items away from static-free work areas: soldering guns, food, hand cream, paper, nonconductive plastic, plastic foam, and cardboard.

Calibration of the Microcomputer Printed Circuit Board

This procedure is to be used on RC-5C, RC-5C *Plus*, and RC-5C *Plus* Brushless centrifuges.

Imbalance Detector Calibration

Each rotor has a predetermined maximum weight in grams of imbalance that when detected causes the OUT OF BALANCE advisory message to light and the centrifuge to shut down.

NOTE:

For proper imbalance detector calibration, the centrifuge must be level and evenly supported on its casters and two front locking stabilizers.

1. Remove the six (6) mounting screws which secure the front control panel to the console. Leave the panel in place.

2. On the Microcomputer Printed Circuit Board, adjust R48 until +3.0 vdc is achieved between wiper of R48 and TP14.

3. Set up the centrifuge as follows:

   a. Set the RPM switches to 2000.
   b. Set TEMP°C RUN switches to 04 and TEMP°C MAX switches to 10.
   c. Set ACCESSORY MODE switches to OFF.
   d. Set TIMED/HOLD switch to HOLD.
   e. Set OFF~BRAKE switch to BRAKE.
   f. Install a rotor in centrifuge, precool if necessary, refer to paragraph 4-8.

NOTE:

For proper calibration of the imbalance detector the TEMP °C display must show 4°C. Precool the rotor, if necessary, refer to paragraph 4-8.

The imbalance detector calibration is most easily accomplished using an SS-34 rotor. When set with the minimum and maximum weights specified for an SS-34 rotor, all other rotors should meet the specification for minimum and maximum weight limits as specified in Table 7-1. If an SS-34 rotor is not available, check each rotor individually with the weights specified in Table 7-1.

Imbalance Detection Threshold:

Rotor (Unloaded)	Imbalance Threshold	
	Minimum Weight (grams)	Maximum Weight (grams)
SS-34	20 g	60 g
SA-600	20 g	60 g
GSA	60 g	120 g

g. Place the minimum weight in the bottom of one of the rotor tube compartments (refer to Table 7-1). Secure the lid on the rotor and close the centrifuge chamber door.

NOTE:
One U.S. nickel is equal to approximately 5 grams. Two U.S. quarters and one U.S. penny is equal to 15 grams. Three U.S. quarters and one U.S. penny is equal to 20 grams.

h. When the displayed temperature is 4°C, press the START switch.

4. Observe the OUT OF BALANCE advisory message as the rotor accelerates to 2000 rpm. If the minimum weight causes the OUT OF BALANCE advisory message to light and the centrifuge to shut off, the detector is too sensitive.

   a. Tilt the front panel forward and adjust R48 on the Microcomputer PC Board clockwise to decrease imbalance sensitivity.
   b. Press the START switch.
   c. Repeat step 4.

   If the minimum weight does not cause the OUT OF BALANCE advisory message to light:

   a. Press the STOP switch.
   b. Leave the rotor on the drive spindle. Remove the minimum weight from the tube compartment and place it in the opposite tube compartment.
   c. Press the START switch.
   d. Repeat step 4.

If the minimum weight in the opposite tube compartment causes the OUT OF BALANCE advisory message to light and the centrifuge to shut off, the detector is too sensitive.

a. Adjust R48 on the Microcomputer PC Board clockwise to decrease imbalance sensitivity.
b. Press the START switch.
c. Repeat step 4 for minimum weight in opposite tube compartment.

If the minimum weight in the opposite tube compartment does not cause the OUT OF BALANCE advisory message to light:

a. Press the STOP switch.
b. Leave the rotor on the drive spindle. Remove the minimum weight from tube compartment B.
c. Go to step 5.

5. Install the maximum weight, 20 grams, in the bottom of one of the rotor tube compartments. Secure the lid on the rotor and close the centrifuge chamber door.

6. Press the START switch.

CAUTION:

When the maximum weight is in the rotor compartment, the OUT OF BALANCE advisory message must light by 1200 rpm If it does not, press the STOP switch to terminate the run. Adjust R48 counterclockwise prior to another run.

7. Observe the OUT OF BALANCE advisory message as the rotor accelerates to 2000 rpm. If the maximum weight does not cause the OUT OF BALANCE advisory message to light, the detector is not sensitive enough.

a. Press the STOP switch.
b. Adjust R48 on the Microcomputer PC. Board counterclockwise to increase imbalance sensitivity.
c. Press the START switch.
d. Repeat step 7.

If the maximum weight causes the OUT OF BALANCE advisory message to light and the centrifuge to shut off:

a. Leave rotor on the drive spindle. Remove the maximum weight from the tube compartment and place it in the opposite tube compartment.
b. Press the START switch.
c. Repeat step 7.

If the maximum weight in opposite tube compartment does not cause the OUT OF BALANCE advisory message to light, the detector is not sensitive enough.

a. Press the STOP switch.
b. Adjust R48 on the Microcomputer PC. Board counterclockwise to increase imbalance sensitivity.
c. Press the START switch.
d. Repeat step 7 for maximum weight in opposite tube compartment.

If the maximum weight in opposite tube compartment causes the OUT OF BALANCE advisory message to light and the centrifuge to shut off:

a. Leave the rotor on the spindle. Remove the maximum weight from tube compartment.
b. Go to step 8.

8. Recheck imbalance detector sensitivity with minimum weight.

9. Reinstall the front control panel with the four mounting screws.

10. Remove the rotor from the centrifuge.

11. Set the main circuit breaker, POWER switch, to OFF.

Top Speed Control Adjustment:

On the RC-5C and RC-5C *Plus* centrifuges using brush type motors the only adjustment for the speed control is for maximum speed. On the RC-5C *Plus* Brushless centrifuges the SR Drive is simply set for –2.5 vdc and the PIC processor located on the Drive Interface Board controls the top speed via the PICs firmware.

NOTE:

On RC-5C and RC-5C *Plus* centrifuges that use brush type motors the current limit circuit must be properly calibrated before adjusting top speed. On RC-5C *Plus* centrifuges using Brushless motors there is no current limit circuit.

1. Set the main circuit breaker, POWER switch, to ON.

2. Install an SS-34 rotor in the centrifuge.

3. Close the centrifuge chamber door.

4. Set the main circuit breaker, POWER switch, to OFF.

5. Disconnect the power cord from the power supply.

6. Remove the right panel to access circuit breaker. Then, connect a Digital Volt Meter at a convenient location inside the centrifuge to monitor line voltage.

7. Remove the front control panel from the console frame and place it on the centrifuge top deck.

8. Connect the power cord to a power supply.

Note:
For RC-5C *Plus* centrifuges that use the brushless motor skip to step #12.

9. Set up the centrifuge as follows:

    a. Set the TEMP°C RUN switches to 04 and TEMP°C MAX switches to 10.
    b. Set the RPM switches to 10 000.
    c. Run the centrifuge until TEMP °C display shows 4.
    d. Set the ROTOR CODE switches to 06.

10. When TEMP°C display shows 4, set the RPM switches to 21 000.

NOTE:
Disregard the ENTRY ERROR advisory message.

11. Observe and record the line voltage while the rotor is accelerating.

12. Set the SR drive voltage to a starting point of -2.5 vdc by adjusting R26 on the Microcomputer PC. Board (on centrifuges using a brush type motors if this voltage is set too low an overcurrent shutdown will occur). Observe the change in voltage at TP7.

NOTE:
On centrifuges that use the Brushless motor the top speed calibration is complete. The remaining steps pertain to the centrifuges that use the brush type motors only.

13. Adjust R26 on the Microcomputer PC. Board clockwise / counterclockwise (clockwise decreases speed; counterclockwise increases speed) to attain 20,400 rpm (+200~ -0) at 208 Vac. Refer to figure 7-1 for the correct speed and line voltage specifications.

NOTE:
If the line voltage varies as the compressor cycles, the voltage variation can cause the top speed to vary.

14. When the specified rpm is attained, press the STOP switch.

15. Reinstall the front control panel.

16. Open the centrifuge chamber door and remove the rotor.

16. Set the main circuit breaker, POWER switch, to OFF.

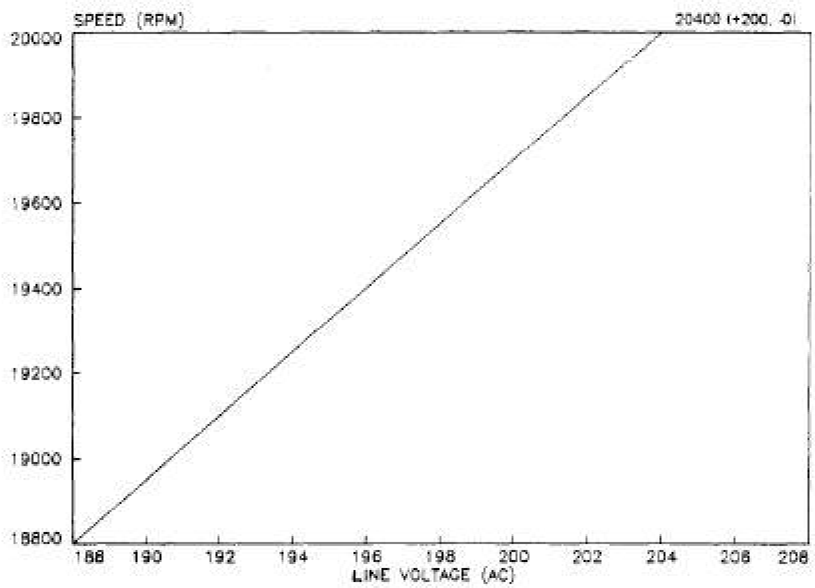


Figure 7-1. RC-5C PLUS Speed vs Line Voltage

Temperature Control Calibration:

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the power supply.

3. Remove the front cabinet panel.

4. Using the door lock override button, open the centrifuge chamber door.

CAUTION:
Before immersing the air temperature sensor into the ice bath, place it into a disposable plastic bag (or similar wrapping). Failure to do so could result in damage to the temperature sensor.

5. Remove the air temperature sensor and place in a disposable plastic bag.

6. Immerse the air temperature sensor in an ice bath, figure 7-2. Reconnect the sensor to the main harness, maintaining correct polarity: black to black, red to white.

NOTE:

To achieve a temperature of 0°C, use only crushed ice (not ice cubes) in the ice bath. To ensure accurate calibration of the temperature control circuit monitor the temperature of the ice bath with a thermometer. The sensor must be stabilized in the ice bath for 10 minutes prior to calibration. Agitate sensor in ice bath for 10 to 15 seconds prior to calibration. Continue with calibration procedure while waiting for sensor to cool.

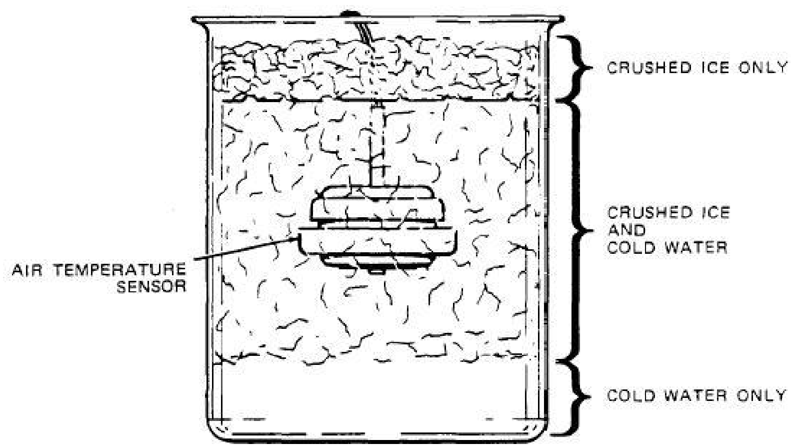


Figure 7-2. Air Temperature Sensor in Ice Bath

7. Remove the front control panel and rest it on the centrifuge top deck.
8. Zero the A/D converter as follows:

   a. Disconnect P3 from the Microcomputer PC Board.
   b. On the Microcomputer P.C. Board either set switch S2 from NORM to DIAG or connect pins at S2 with jumper wire or plug.
   c. Connect a jumper wire from TP4 to J3 Pin 8.

NOTE:

Jumper wire must be connected to the ground of J3-8 and not TP14. Using TP14 as ground will offset the actual temperature reading by approximately 2°C.

   d. Set up the centrifuge as follows:
      - Connect the power cord to a power supply.
      - Set the main circuit breaker, POWER switch, to ON.

- Press the RCF switch. The front control panel blanks and the HOLD advisory message lights.
- Set the ROTOR CODE switches to 40.
- Press the START switch. The SPEED display fluctuates at this time, disregard it.

e. Adjust R27 on the Microcomputer PC. Board (clockwise decreases value shown in display; counterclockwise increases value shown in display) so that the SPEED display shows a value of -39.90. The display shows: 3990.

The SPEED display is used to show the temperature: four LRDs are used and are read as XX.XX°C. No decimal point is shown in the display, but values may be read to hundreths of a degree. If a lower case letter c appears in the display, a negative temperature is indicated.

f. Set the main circuit breaker, POWER switch, to OFF.
a. Disconnect the jumper wire from TP4 and J3-8.

9. Adjust the slope and intercept using the Temperature Calibration Box and a milli-amp meter as follows:

a. Connect the Temperature Calibration Box to J3.

NOTE:
Ensure proper orientation of the connector.

b. Connect the milli-amp meter to meter output of Temperature Calibration Box. Set the meter to dc m amp range.

NOTE:
Use only milli-amp meters with 0.1% or better. One microamp is equal to 1°C.

c. Set up the centrifuge as follows:

- Set the main circuit breaker, POWER switch, to ON.
- Press RCF switch.
- Press START switch.

d. Set Temperature Calibration Box switches to LOW and CAL positions. The m amp meter should read 239 micro amps. If the meter does not read 239 m amps, open the Temperature Calibration Box and adjust the potentiometer, figure 7-3.

e. Adjust the intercept using R34 on the Microcomputer PC Board. Turn R34 so that the SPEED display shows a value of -34.00°C ±~.20°C.

f. Set Temperature Calibration Box to HIGH. The m amp meter should read 324 m amps. If meter does not read 324 m amps, open Temperature Calibration Box and adjust the potentiometer, figure 7-3.

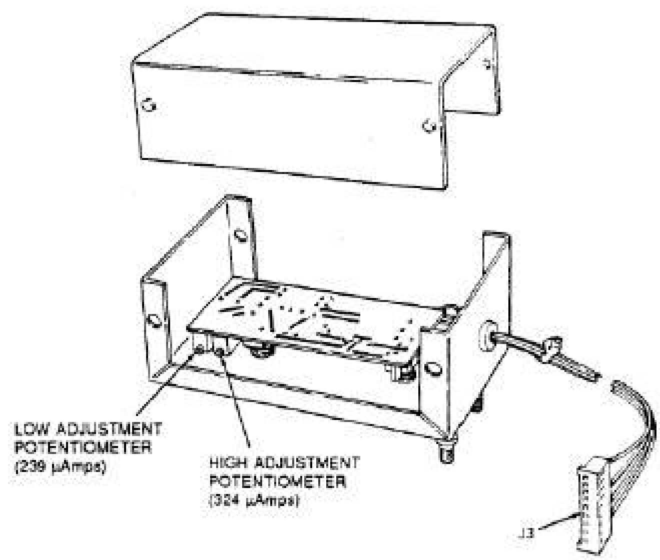


Figure 7-3. Temperature Calibration Box with Back Removed

g. Adjust the slope using R35 on the Microcomputer P.C. Board. Turn R35 so that the SPEED display shows a value of +51.00°C±~.20°C.
h. Recheck the values calibrated for the HIGH (+51.00°C±0.20°C) and LOW (34.00°C ±0.20°C) settings: repeat step 9, d-g
i. Set the main circuit breaker, POWER switch, to OFF.

10. Disconnect the Temperature Calibration Box from J3.

11. Offset the intercept adjustment to compensate for variations in the sensor as follows:

a. Reconnect P3 to the Microcomputer PC Board.
b. Set up the centrifuge as follows:
   - Set the main circuit breaker, POWER switch, to ON.
   - Press RCF switch.
   - Press START switch.
   - Set ROTOR CODE switches to 40.

NOTE:

The air temperature sensor must be stabilized in the 0°C ice bath for 10 minutes before adjusting R34. Agitate sensor for 10 to 15 seconds prior to this adjustment. Monitor the temperature of the ice bath placing thermometer at the same level as the sensor.

c. Adjust R34 on the Microcomputer PC. Board to compensate for manufacturing variations in the air temperature sensor.

   The SPEED display is used to show the temperature: four LEDs are used and are read as XX.XX°C. No decimal point is shown in the display, but values may be read to hundredths of a degree.

   The sensor should be calibrated to 0°C (00 00 ~ 00.00°C on the SPEED display), however if the temperature of the ice bath is not 0.0°C, adjust R34 so the SPEED display shows the actual temperature of the ice bath as read on the thermometer. It is normal for the display to fluctuate several tenths of a degree. If a lower case letter c appears in the display, a negative temperature is indicated.

d. Set the main circuit breaker, POWER switch, to OFF.

12. Reinstall the front control panel.

13. Reinstall the air temperature sensor.

14. Reinstall the front cabinet panel.

Current Limit Calibration:

This procedure is to be used on RC-5C and RC-5C *Plus* centrifuges that use brush type motors only.

Current Limit Calibration

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the mains power supply.

3. Remove the rear and left cabinet panels.

4. Attach an amp probe at a convenient location (wire #129 on K103) to monitor the motor current.

5. Connect the power cord to a power supply.

6. Set the main circuit breaker, POWER switch, to ON.

7. Set up the centrifuge as follows:

   a. Set TEMP°C RUN switches to 04 and TEMP°C MAX switches to 25.

NOTE:
For proper calibration, the TEMP°C display must show 4°C. precool the rotor, if necessary.

   b. Open the chamber door and install the rotor.
   c. Set the RPM switches to the maximum rated speed of the rotor in use.
   d. Set the ROTOR CODE switches to the code number for the rotor in use (see Rotor Table).
   e. Set the ACCESSORY MODE switches to OFF.
   f. Set the OFF/BRAKE switch to BRAKE.
   g. Press the START switch.

8. While the rotor is accelerating, adjust R1 on the High Voltage Interface PC Board (clockwise increases current draw) for a maximum current draw of 16.5 amps.

9. Press the STOP switch.

10. Recheck current setting after calibration. The final check should be from zero rpm and during acceleration.

11. Remove amp probe.

12. Open the centrifuge door and remove the rotor.

13. Set main circuit breaker, POWER switch, to OFF.

14. Reinstall the rear and left cabinet panels.

Slow Start Calibration:

This calibration procedure is valid for the RC-5C and RC-5C *Plus* centrifuges that use brush type motors. On RC-5C *Plus* centrifuges that use brushless motors the slow start is set in the firmware program on the PIC processor located on the Drive Interface Printed circuit board.

This calibration is dependent on the voltage level at TP7 on the Microcomputer PC. Board. To provide an accurate voltage level at TP-7, perform Top Speed Control Adjustment prior to this calibration.

1. Set the main circuit breaker, POWER switch, to OFF.

2. Disconnect the power cord from the power supply.

3. Remove the left side cabinet panel.

4. Remove the front control panel.

5. Connect the power cord to a power supply.

6. Set the main circuit breaker, POWER switch, to ON.

7. Install either an SS-34 Rotor, SE12 Rotor, or an SM-24 Rotor.

8. Set the centrifuge run parameters as follows:

   a. Set RUN temperature switch to 4°C and MAX temperature switch 10°C.
   b. Set RPM switches to 20 000.
   c. Set TIMED/HOLD switch to HOLD.
   d. Set the ROTOR CODE switches for the proper ROTOR CODE number.
   e. Close the chamber door.

9. Press the START switch. Allow rotor speed and temperature to stabilize.

10. Calibrate voltages for Slow Start as follows:

    a. Set a Digital Volt Meter (DVM) to AC scale. Then, connect the leads from the DVM to TP-8 and TP-5 on the High Voltage Interface PC. Board.
    b. Adjust R35 (on the High Voltage Interface PC. Board) for a voltage reading of 11.0 volts ±0.2 volts.
    c. Disconnect the leads from TP-8 and TP-5.
    d. Connect leads from the DVM to TP-9 and TP-5 on the High Voltage Interface PC. Board.

e. Adjust R41 (on the High Voltage Interface PC. Board) for a voltage reading of 4.4 volts ±0.2 volts.
f. Disconnect the DVM.

11. Set the POWER switch to OFF.

RC-5C / RC-5C *Plus*
Table of Contents

8.0 Schematic Diagrams

Section 6: PRINTED CIRCUIT BOARDS & SCHEMATIC DIAGRAMS

This section contains a system schematic, wiring diagram as well as schematic diagrams and component description tables for printed circuit boards found in the RC-5C PLUS Centrifuge.

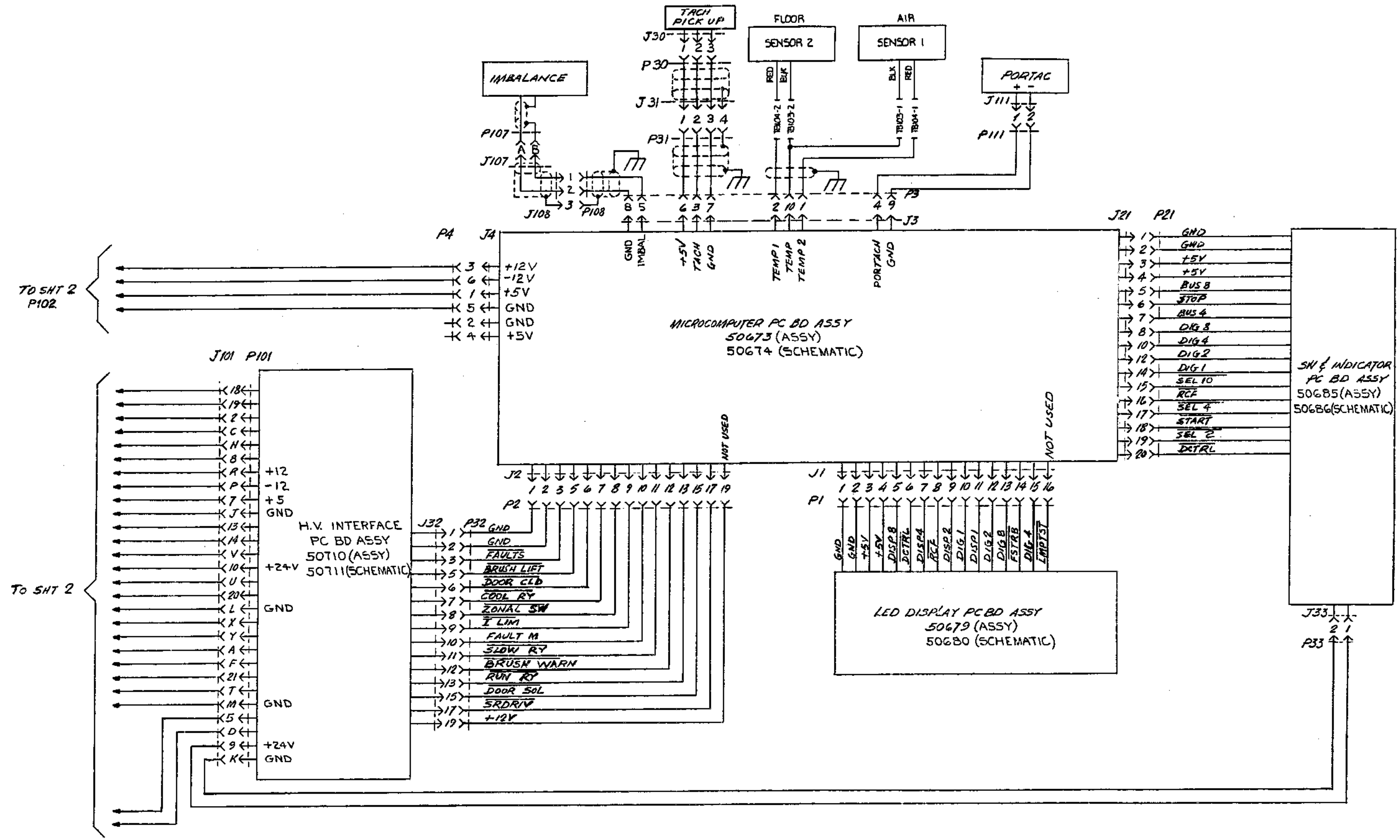


Figure 5-1. RC-5C System Schematic, (50657-5) Sheet 1 of 4

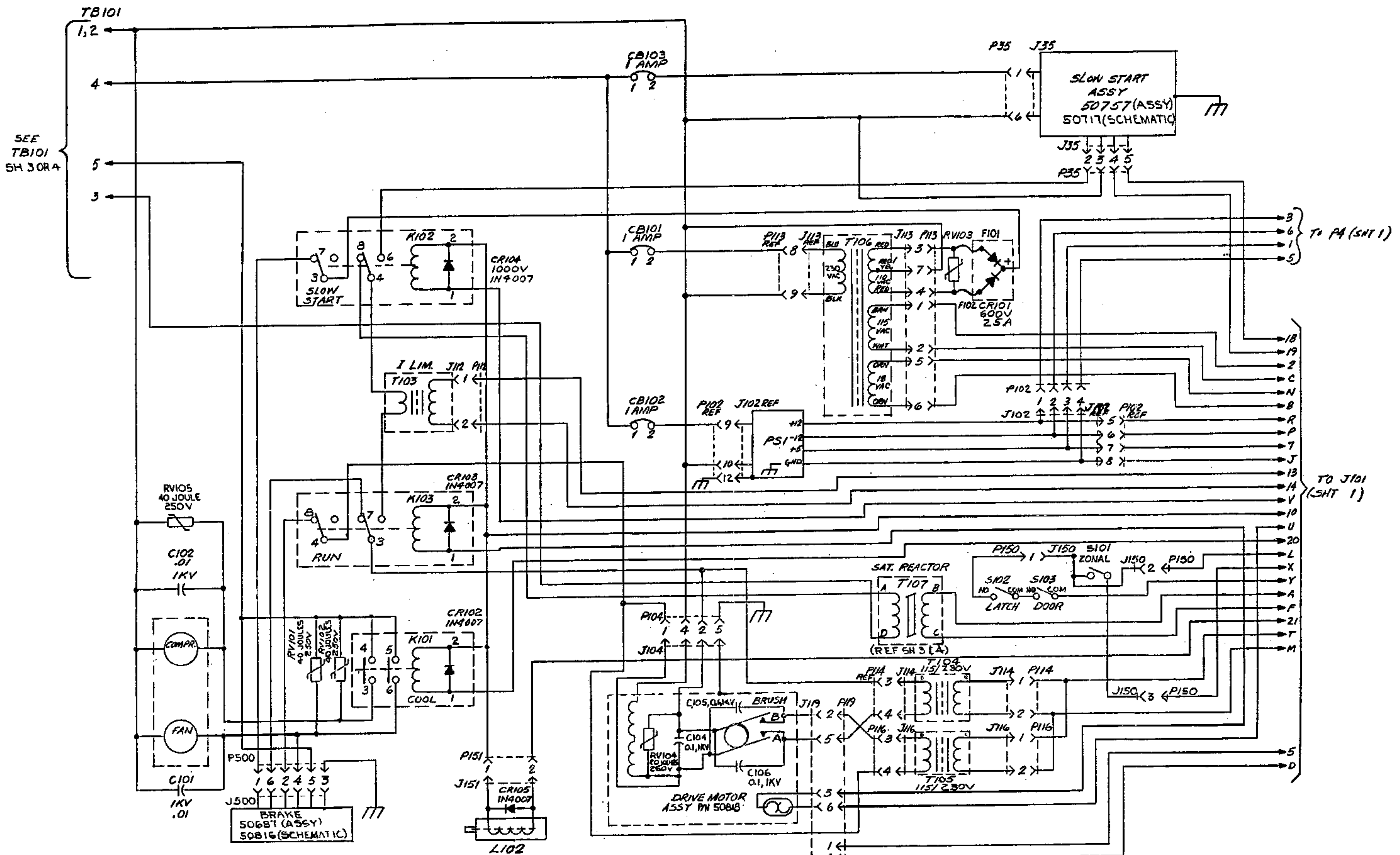
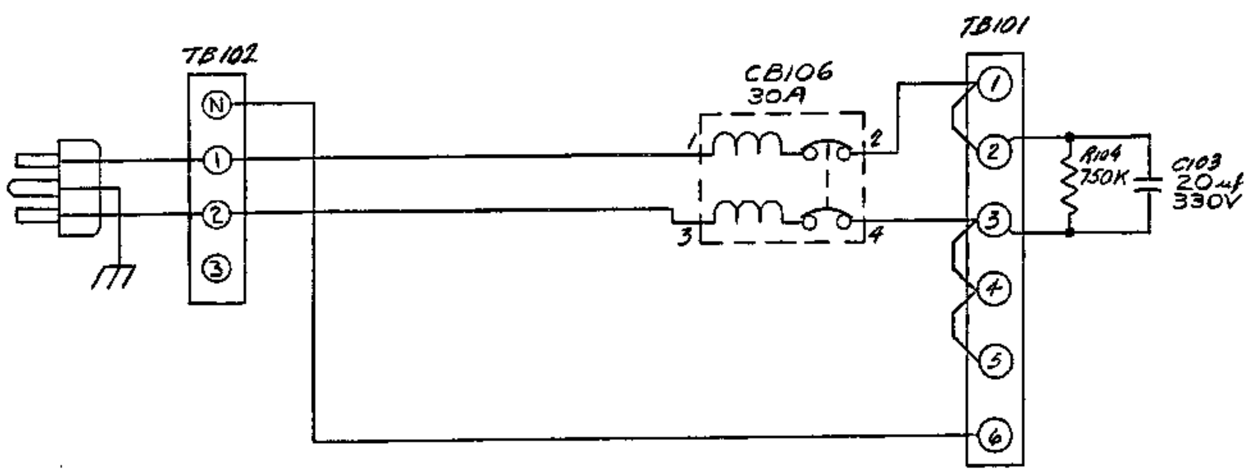
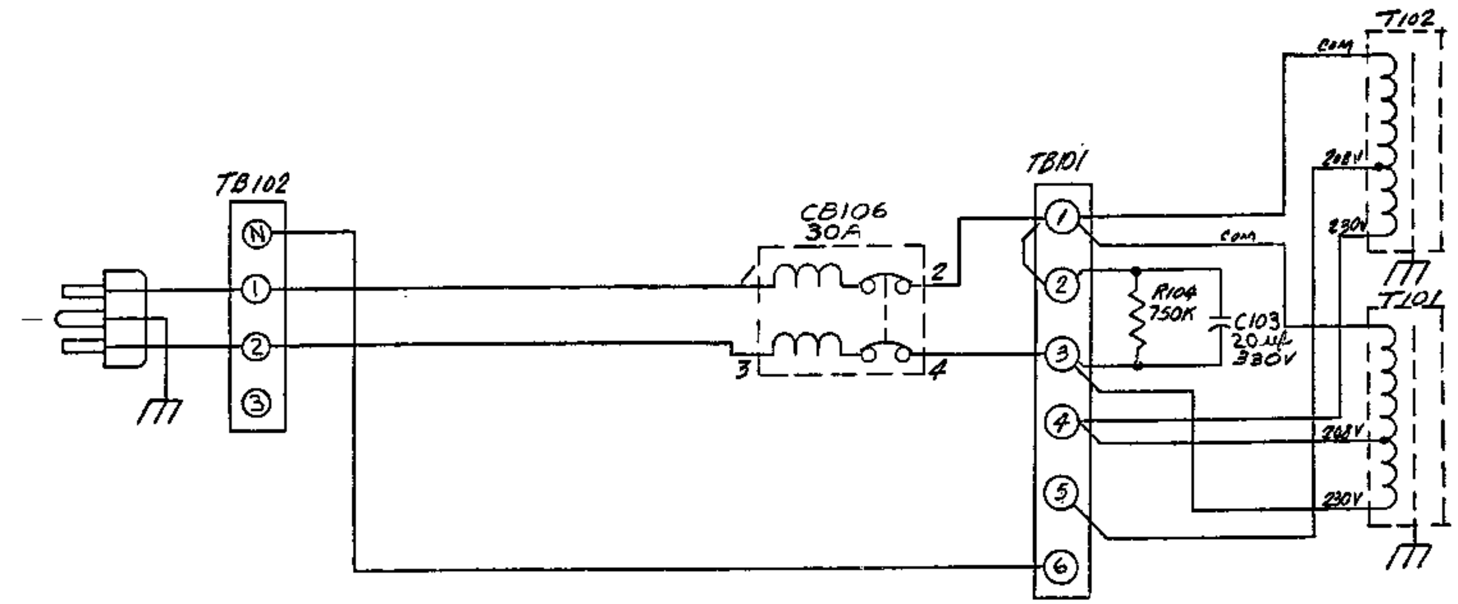


Figure 5-1. RC-5C System Schematic (50657-5) Sheet 2 of 4



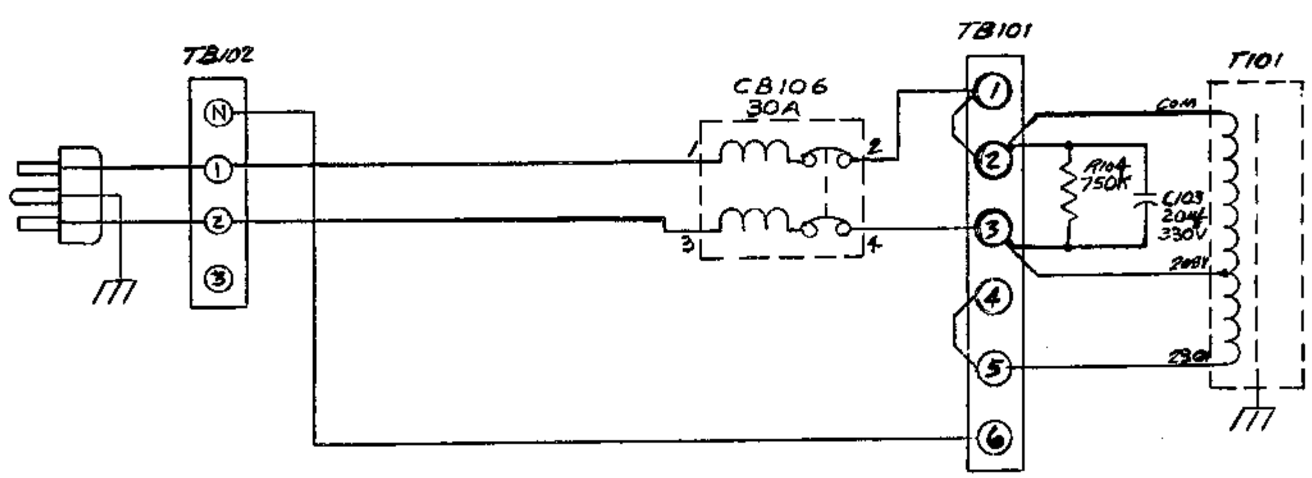
230V, 60HZ

T107 230V OUTPUT WINDINGS USED



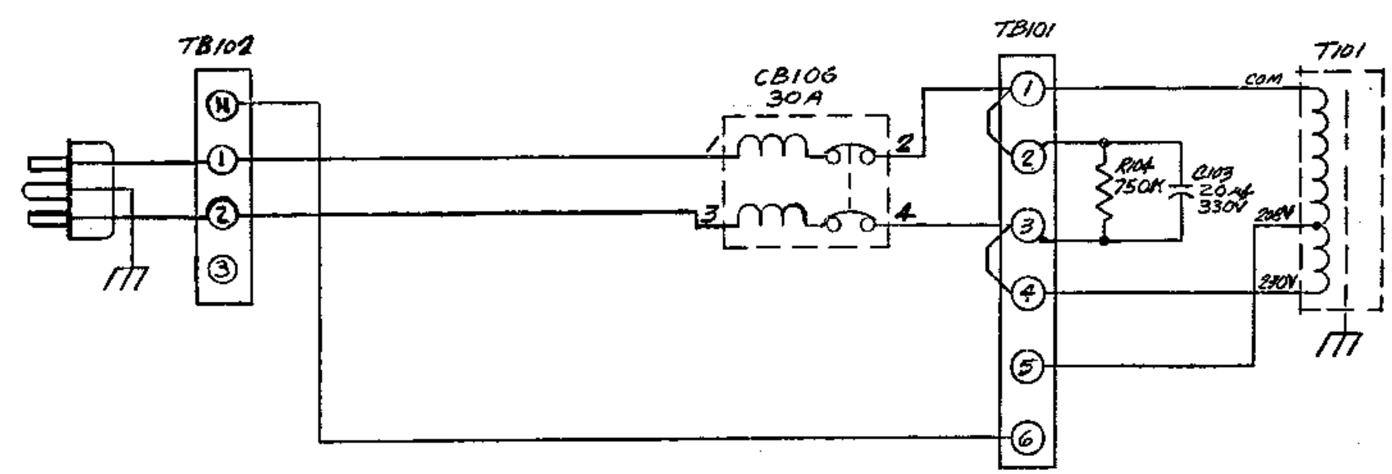
240V, 50HZ

T107 240V OUTPUT WINDINGS USED



208V, 60HZ

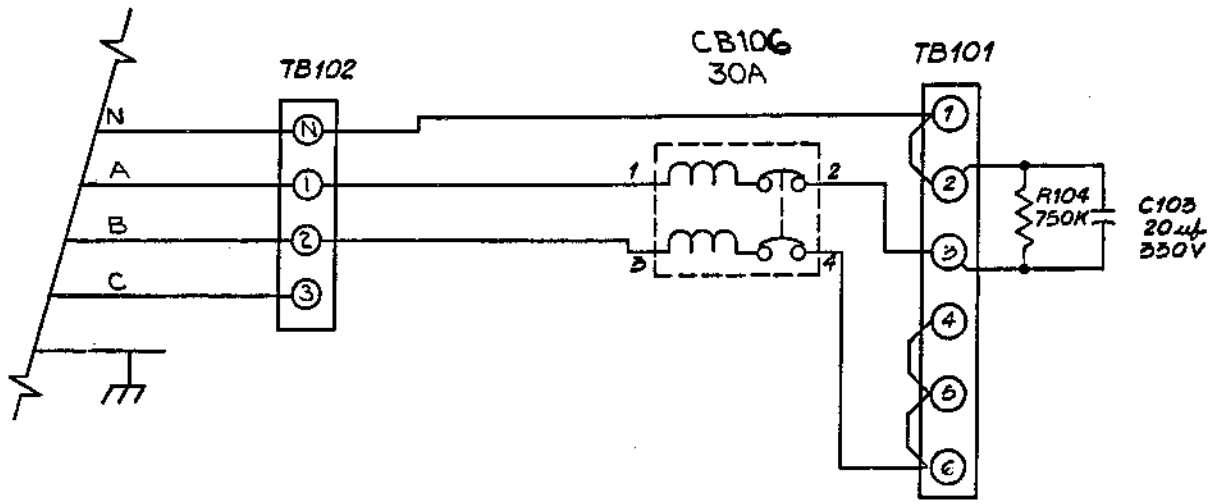
T107 208V OUTPUT WINDINGS USED



220V, 50HZ

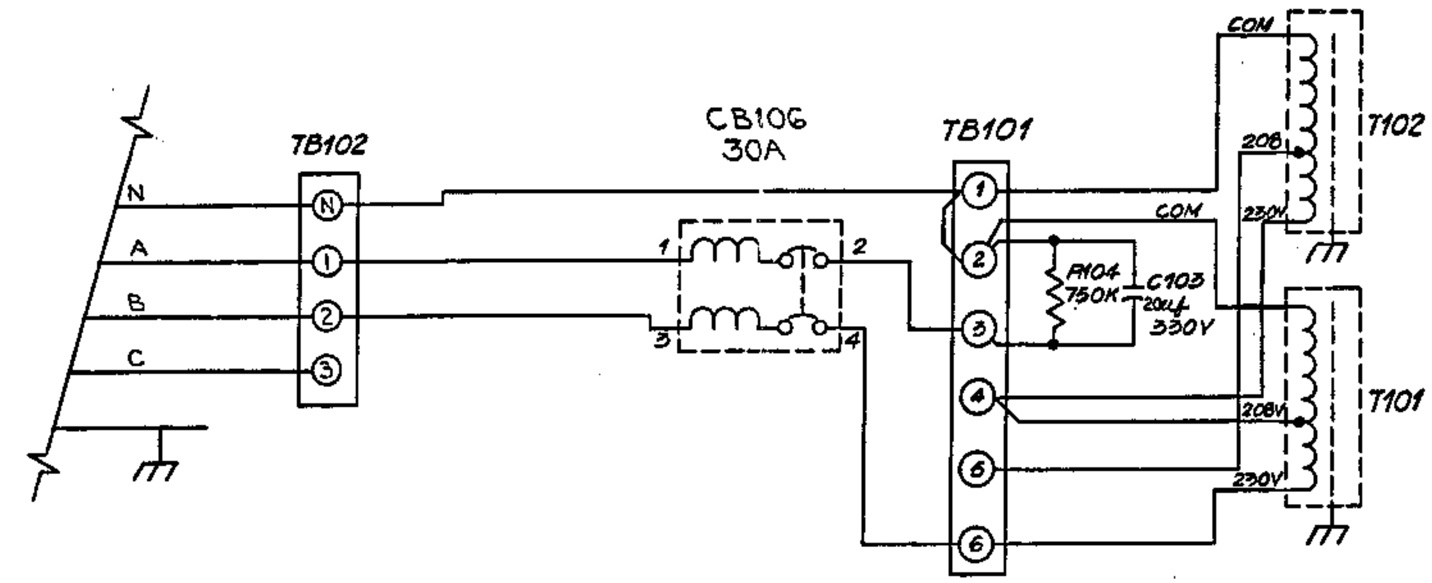
T107 220V OUTPUT WINDINGS USED

Figure 5-1. RC-5C System Schematic, (50657-5) Sheet 3 of 4



230V, 60HZ
POLYPHASE

T107 230V OUTPUT WINDINGS USED



240V, 50HZ
POLYPHASE

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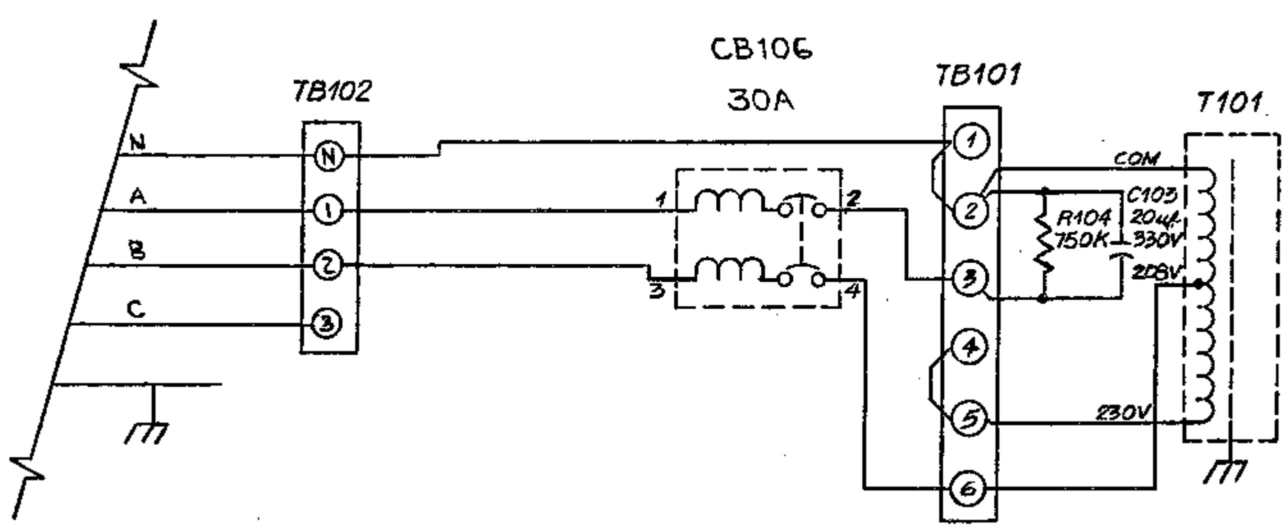
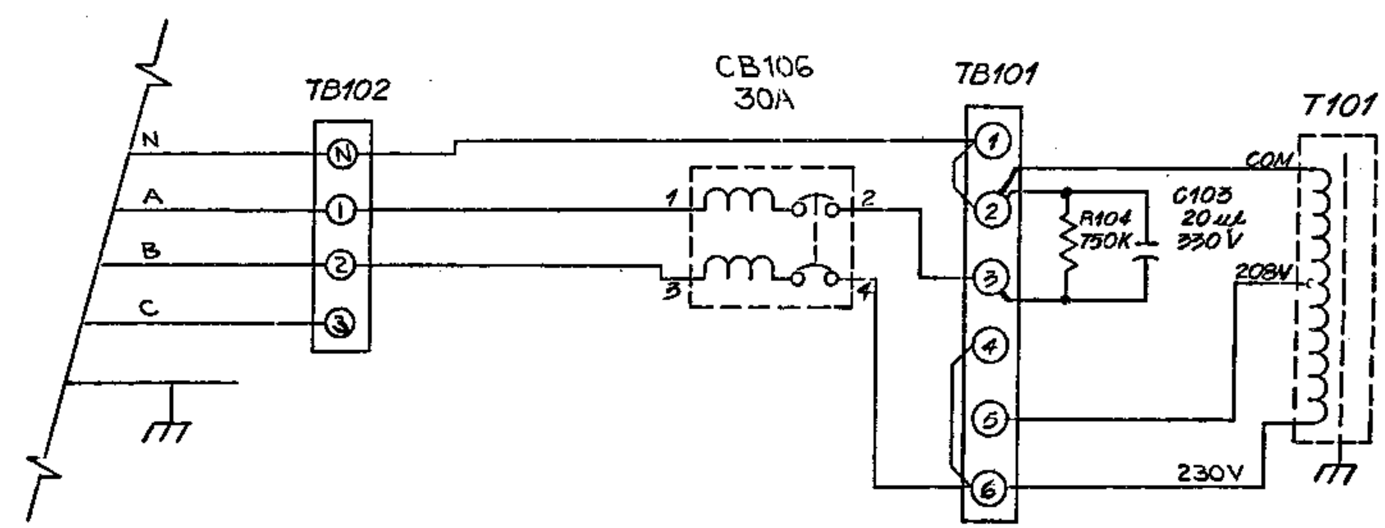


208V, 60HZ
POLYPHASE

T107 208V OUTPUT WINDINGS USED



220V, 50HZ
POLYPHASE

T107 220V OUTPUT WINDINGS USED

Figure 5-1. RC-5C System Schematic,
(50657-5) Sheet 4 of 4

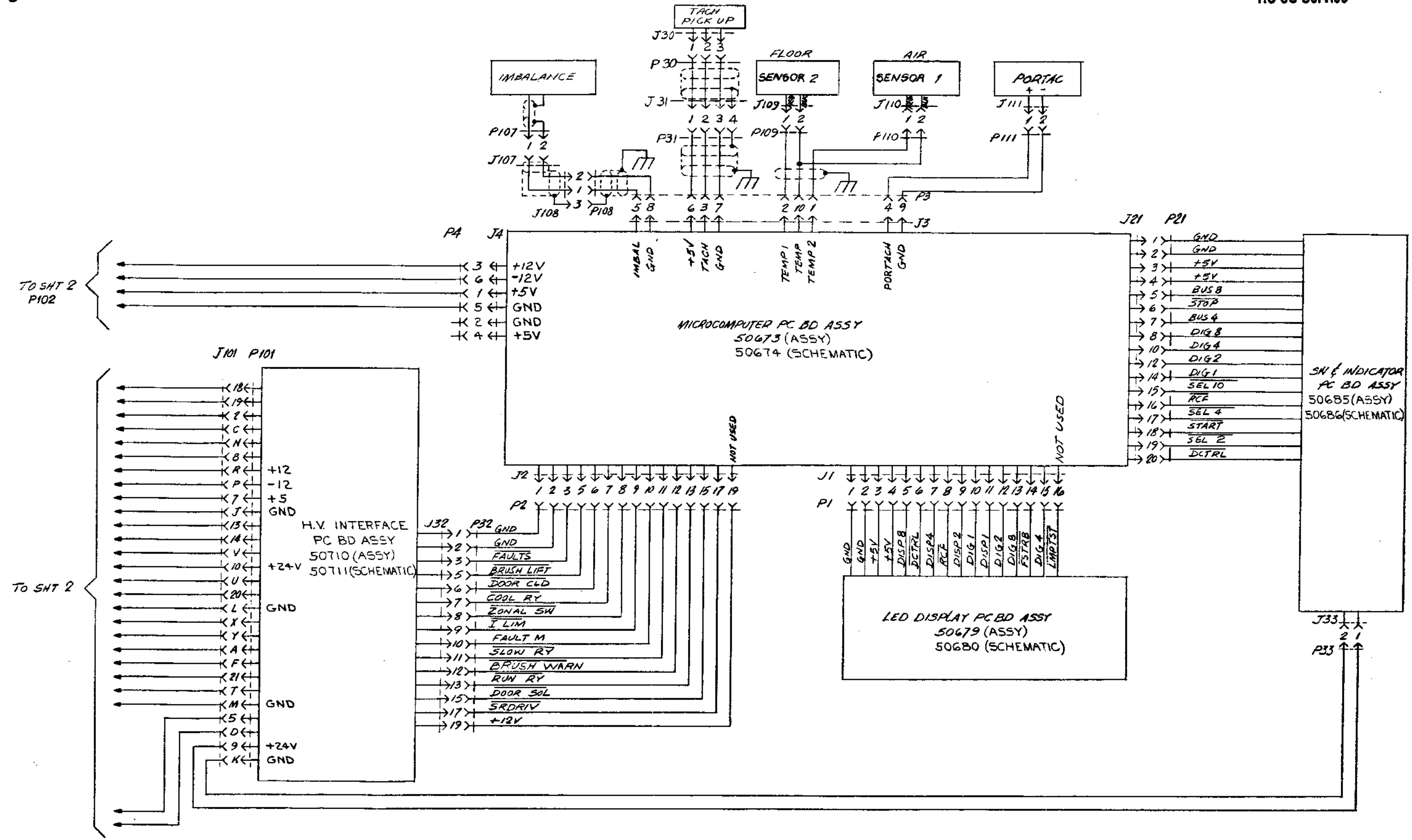


Figure 5-2. RC-5C System Schematic, (50657-1) Sheet 1 of 4

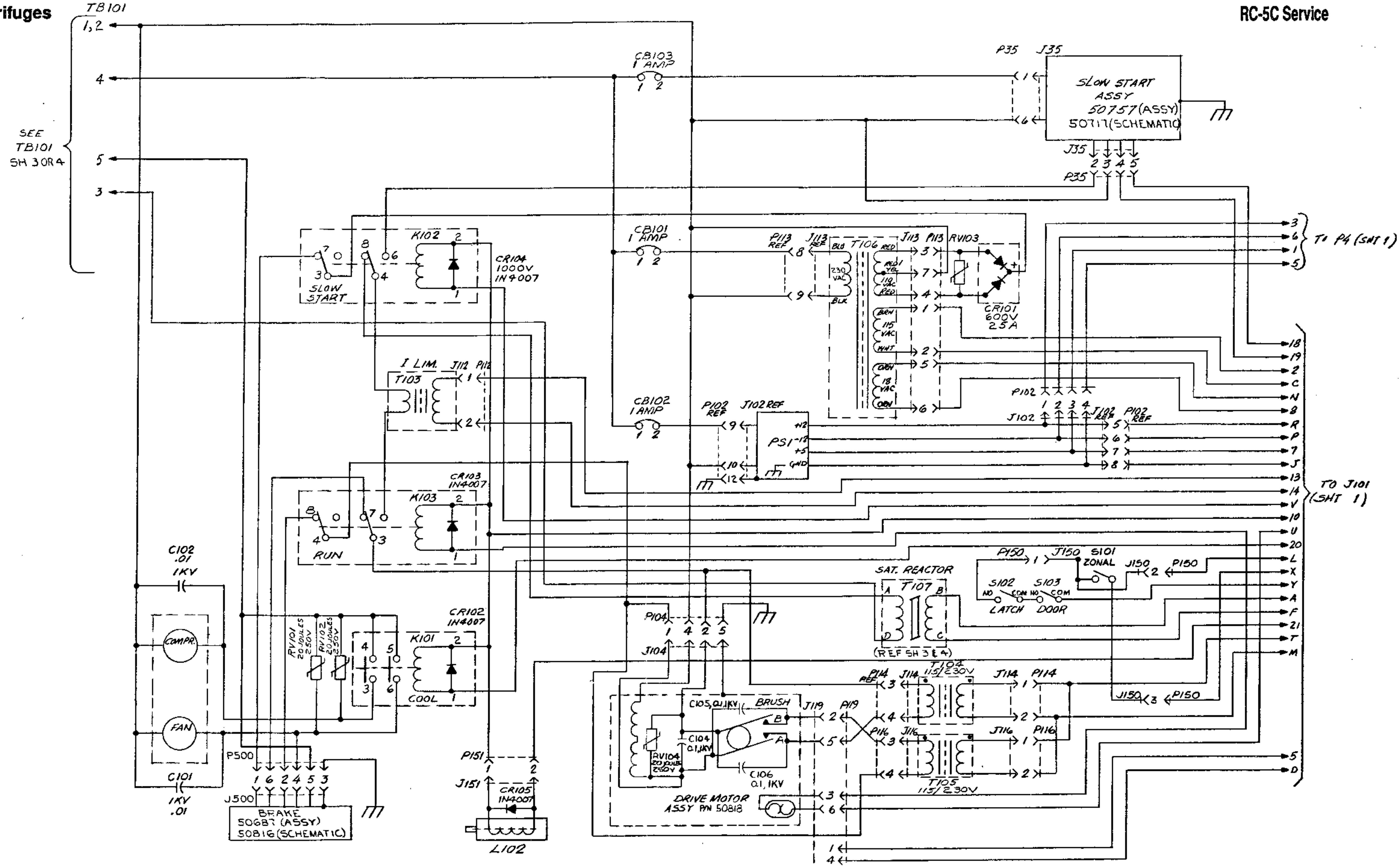
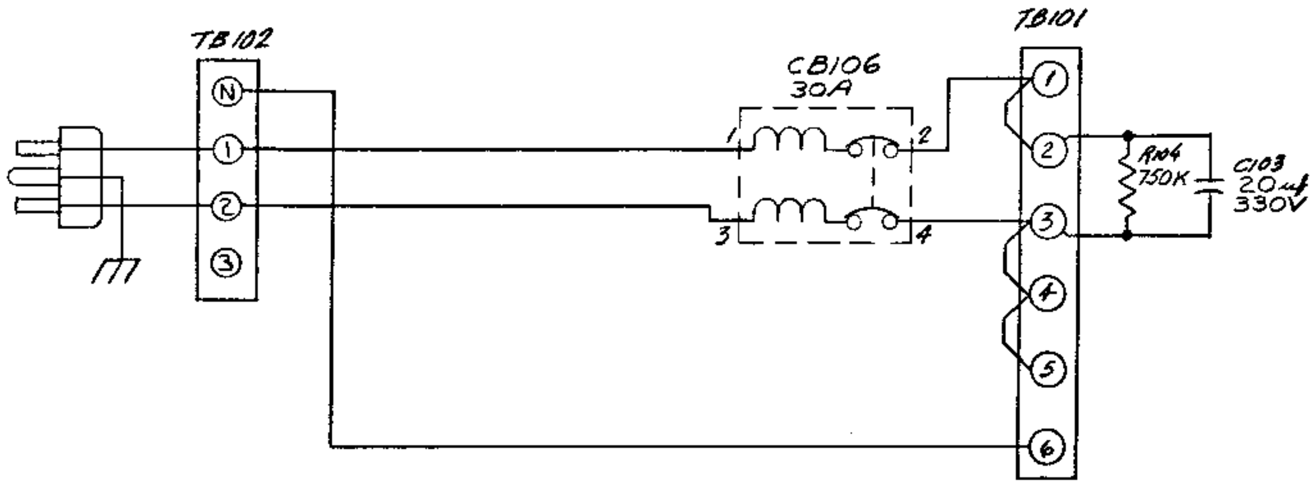
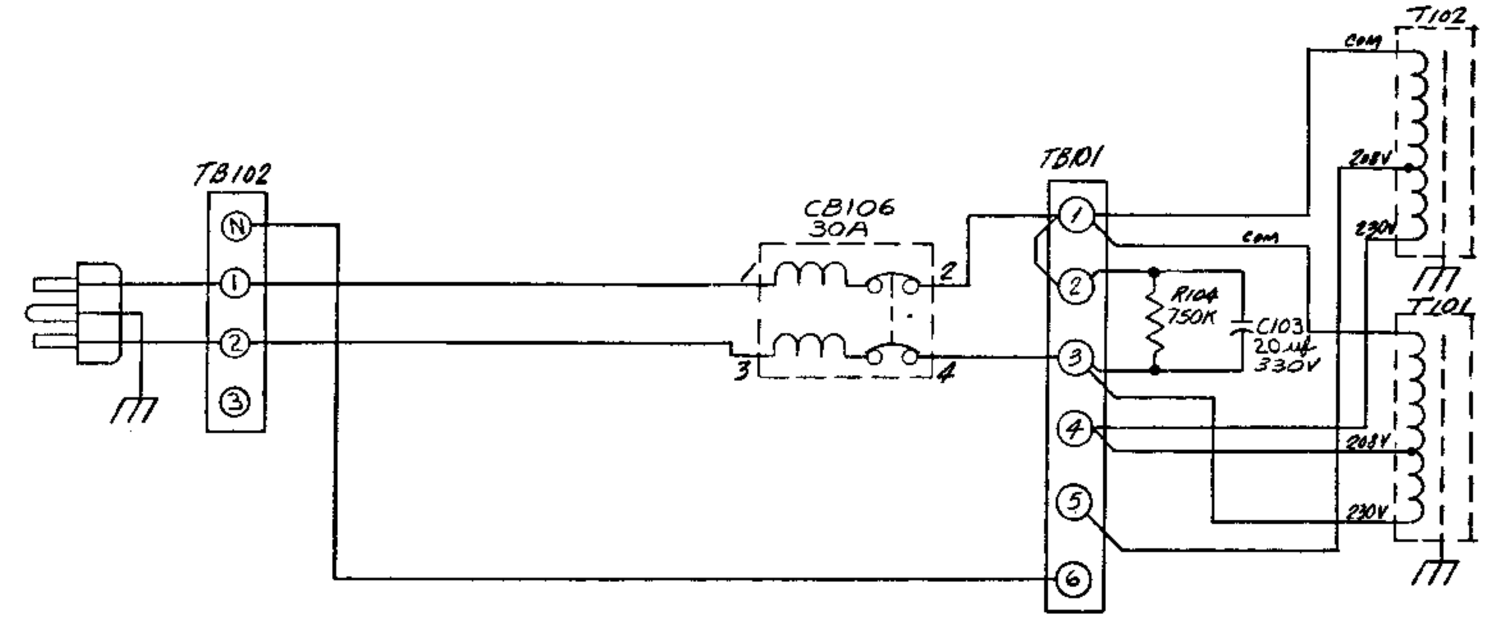


Figure 5-2. RC-5C System Schematic, (50657-1) Sheet 2 of 4



230V, 60HZ
T107 230V OUTPUT WINDINGS USED



240V, 50HZ
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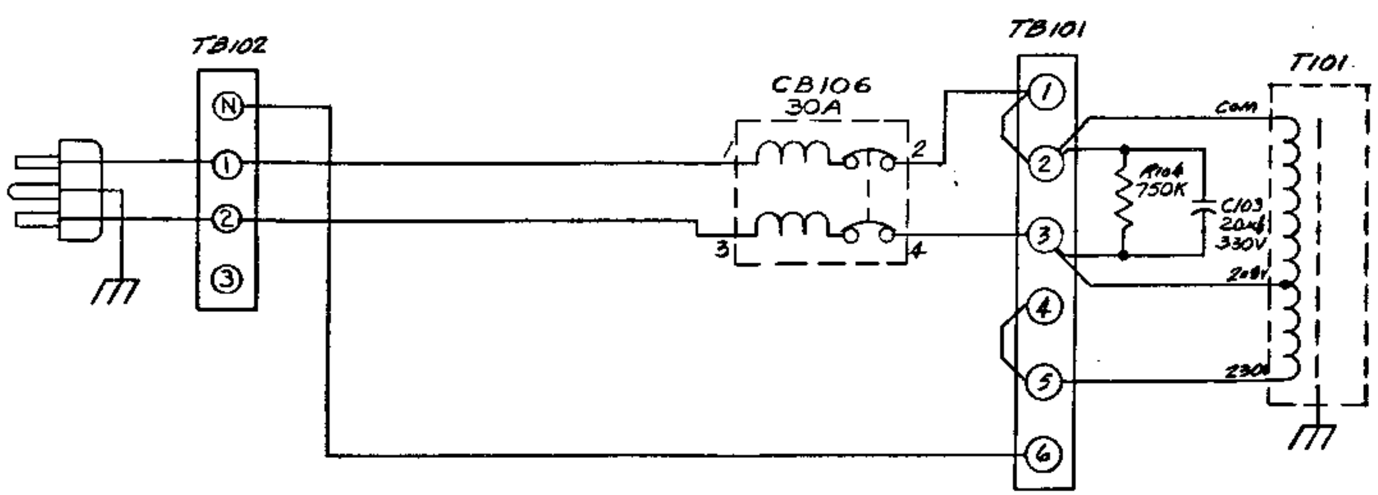

208V, 60HZ
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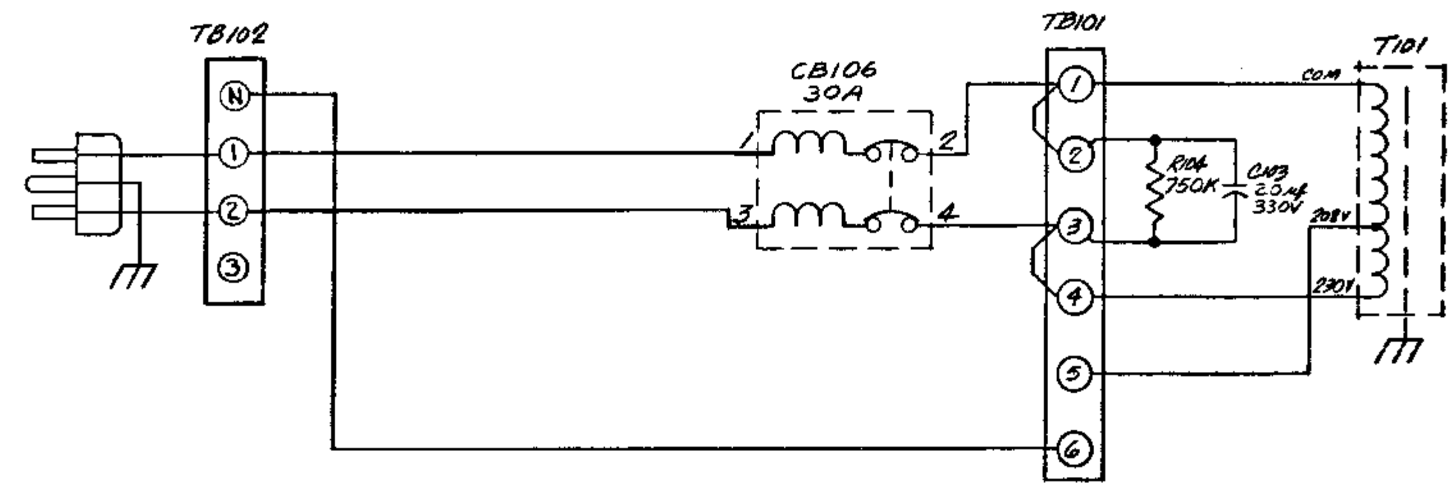
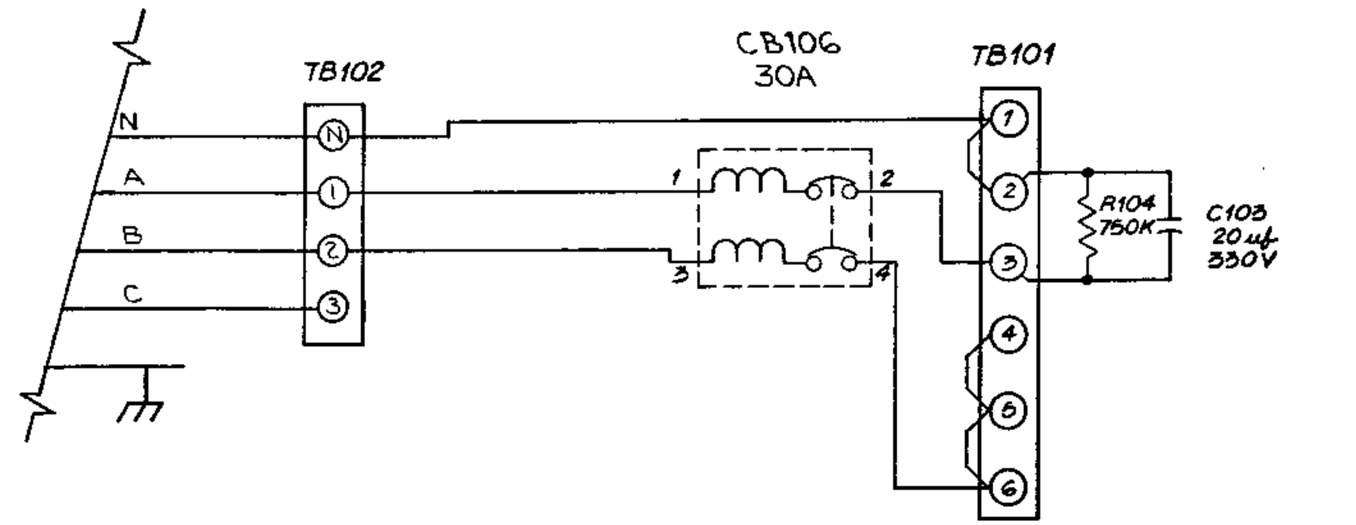


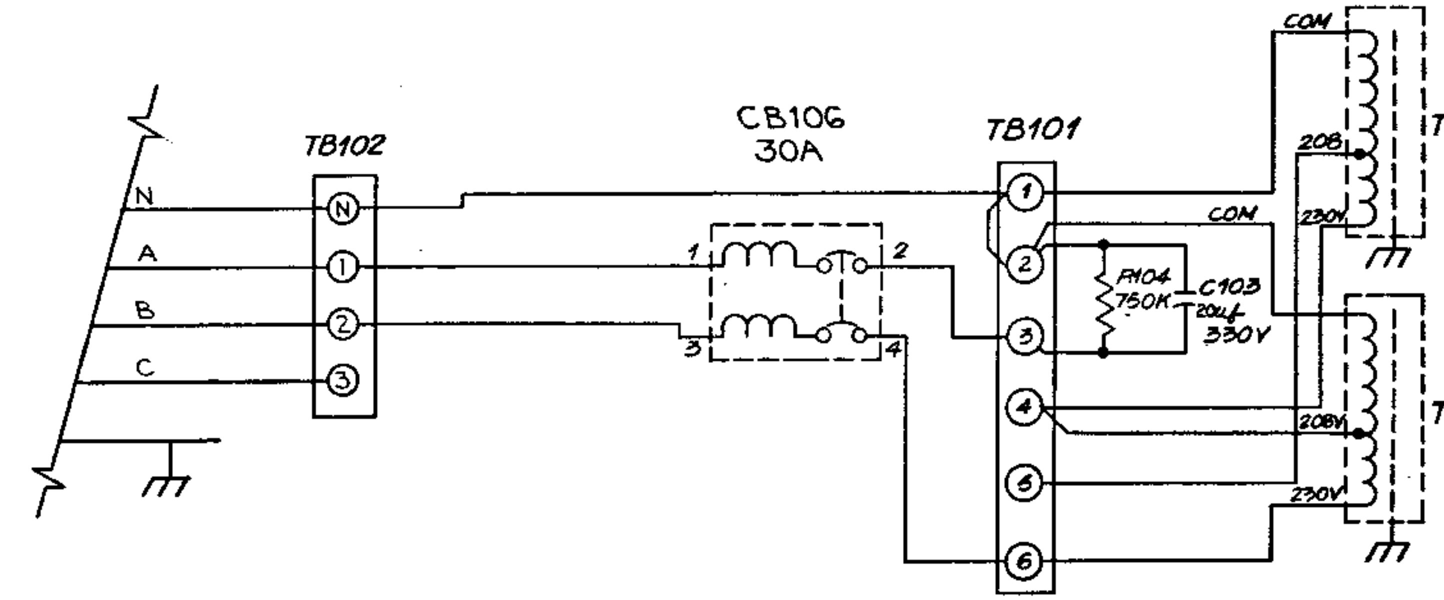
220V, 50HZ
T107 220V OUTPUT WINDINGS USED

Figure 5-2. RC-5C System Schematic, (50657-1) Sheet 3 of 4



230V, 60HZ
POLYPHASE

T107 230V OUTPUT WINDINGS USED



240V, 50HZ
POLYPHASE

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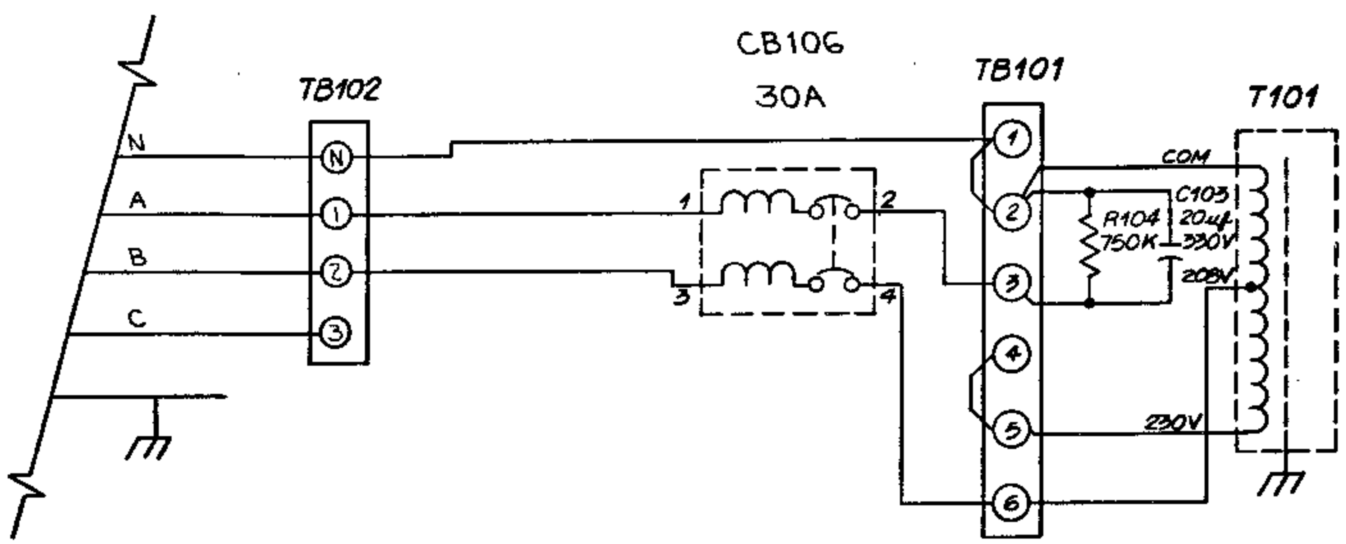
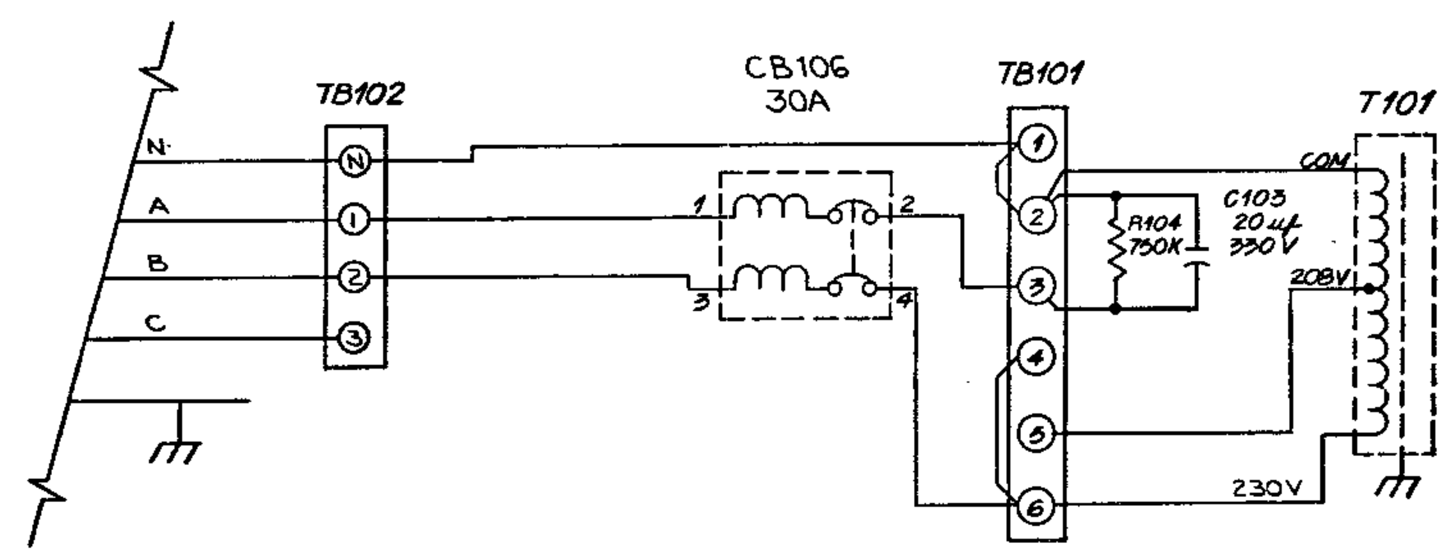


208V, 60HZ
POLYPHASE

T107 208V OUTPUT WINDINGS USED



220V, 50HZ
POLYPHASE

T107 220V OUTPUT WINDINGS USED

Figure 5-2. RC-5C System Schematic, (50657-1) Sheet 4 of 4

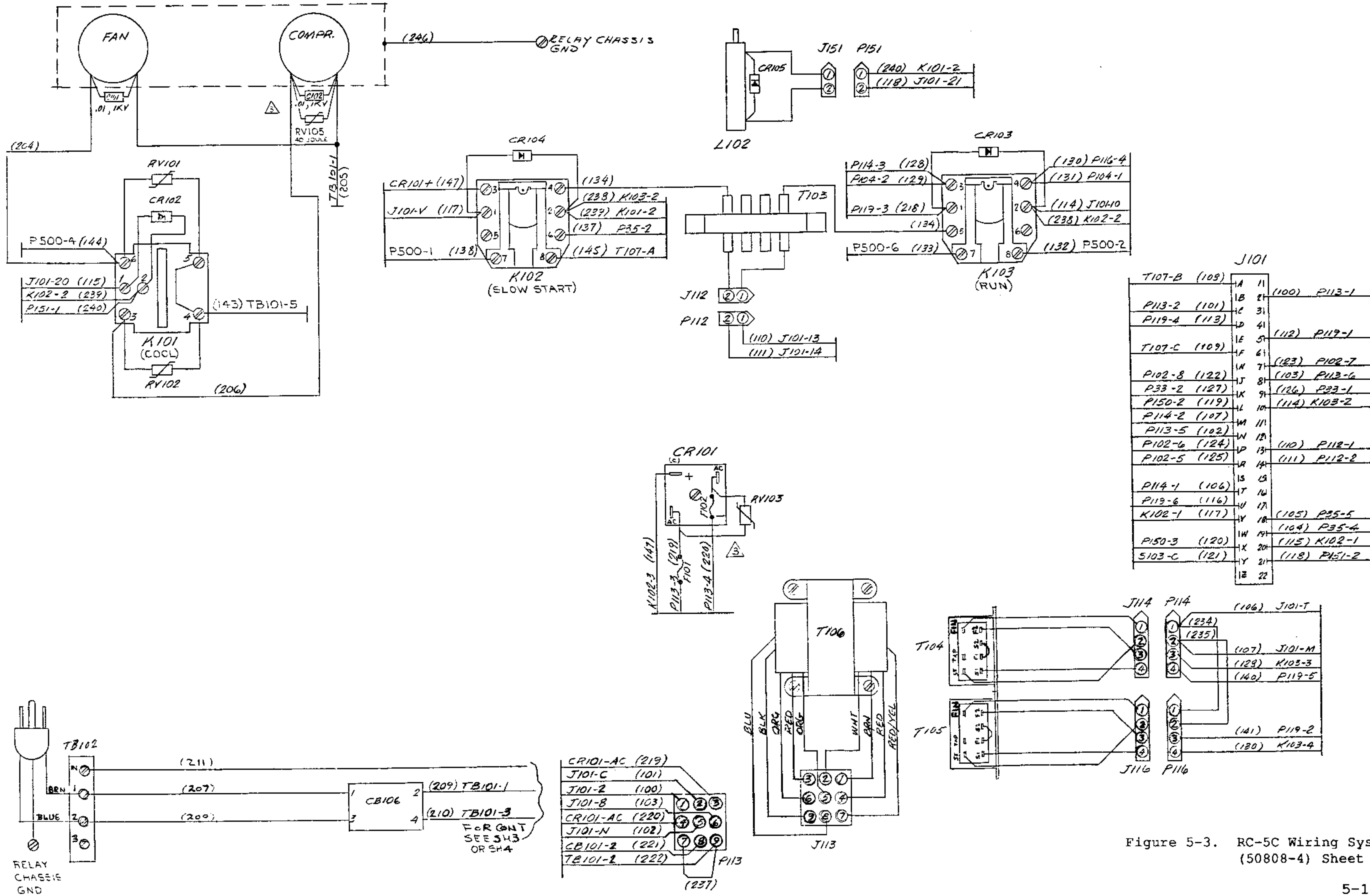


Figure 5-3. RC-5C Wiring System, (50808-4) Sheet 1 of 4

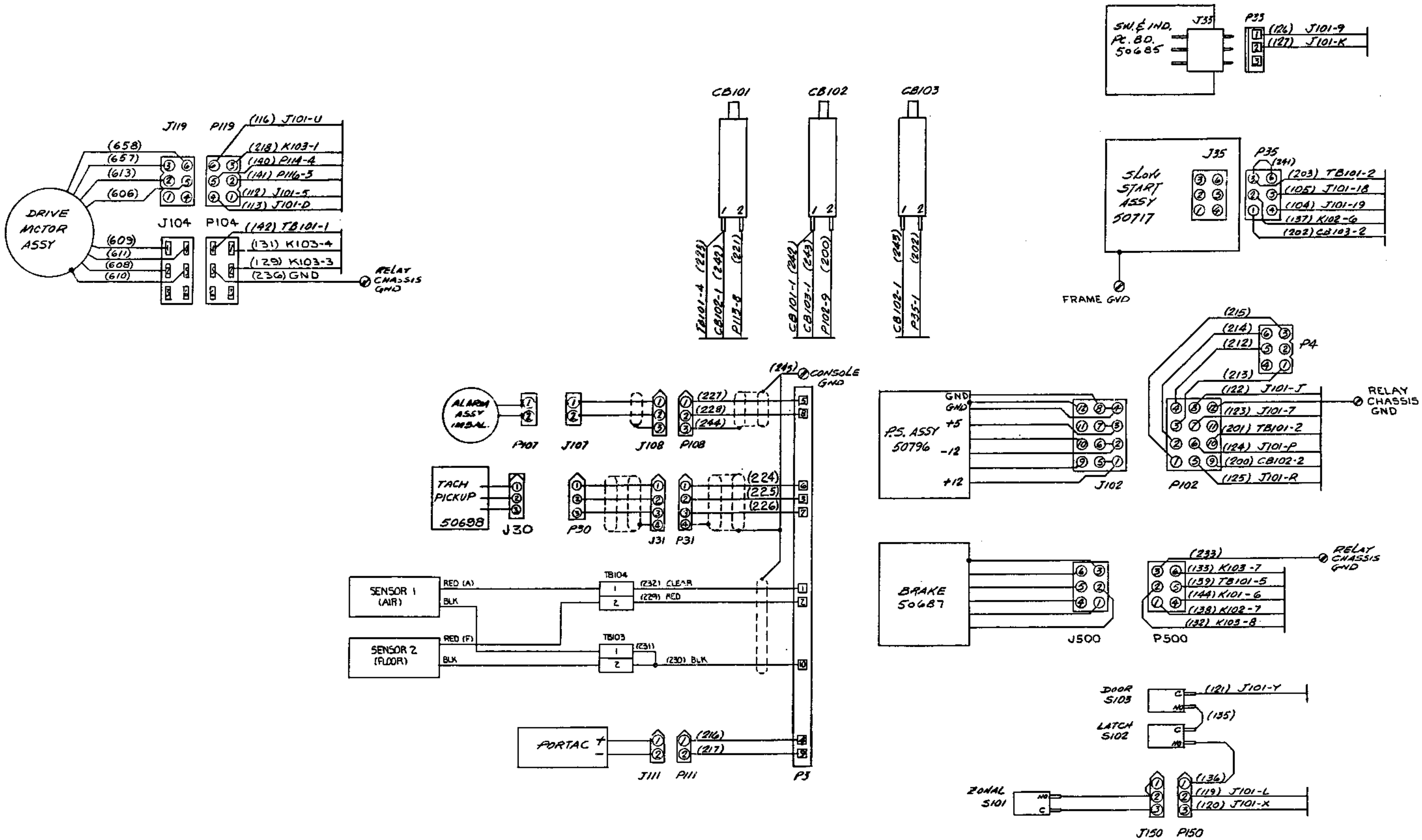


Figure 5-3. RC-5C Wiring System, (50808-4) Sheet 2 of 4

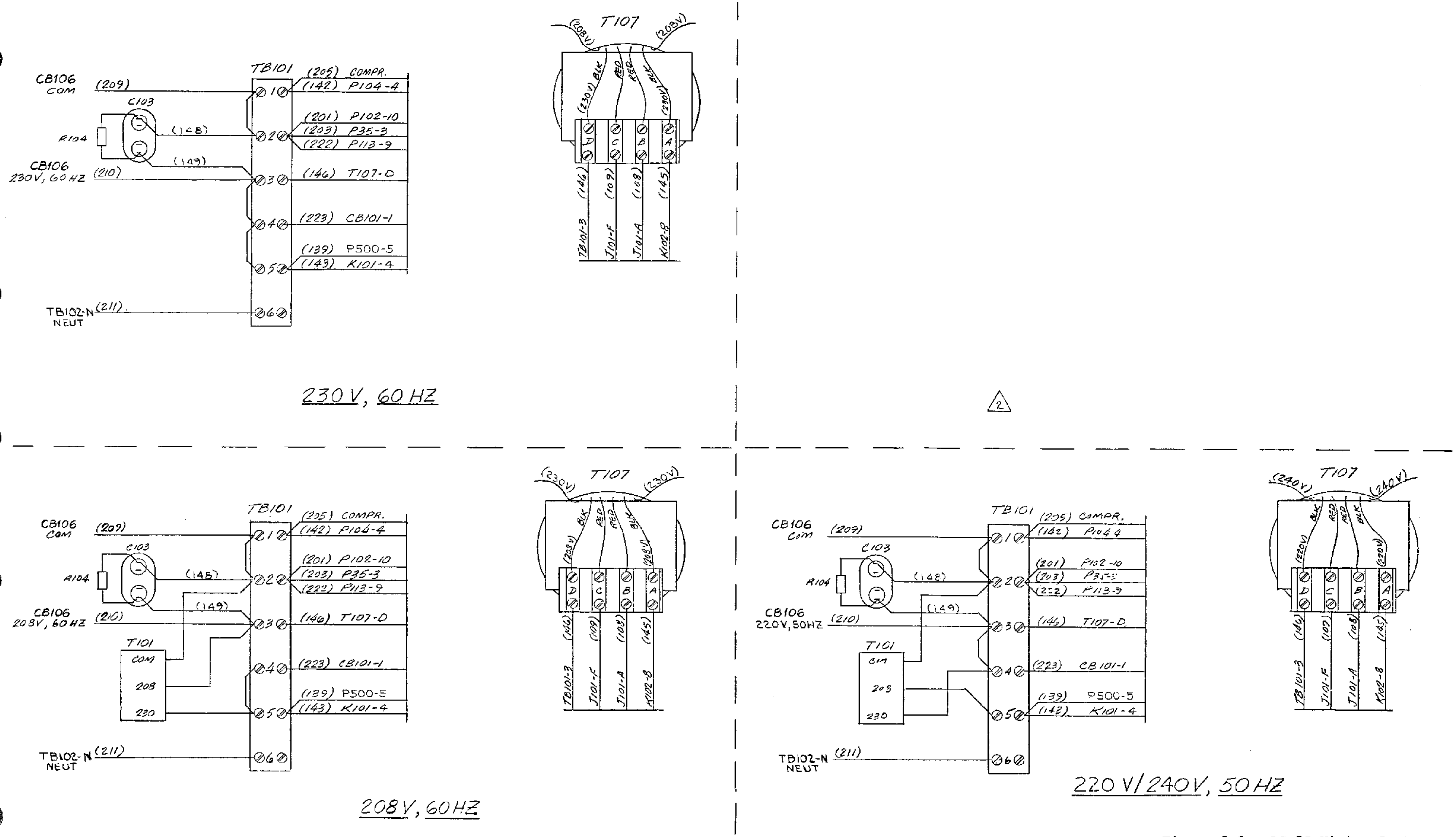
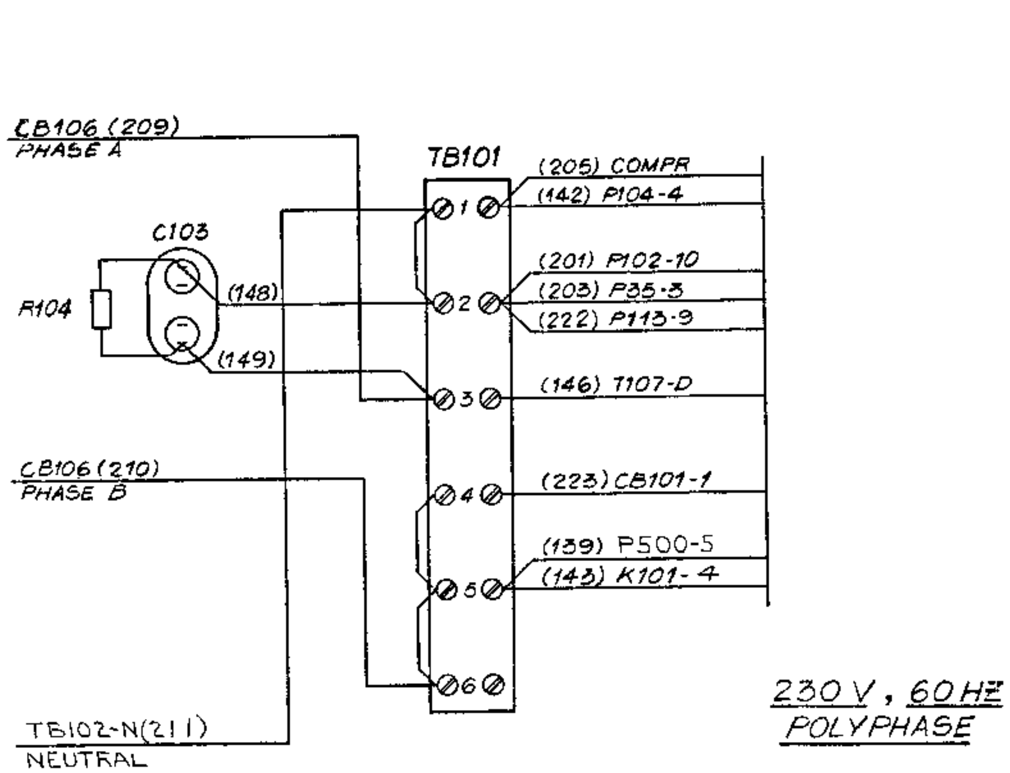
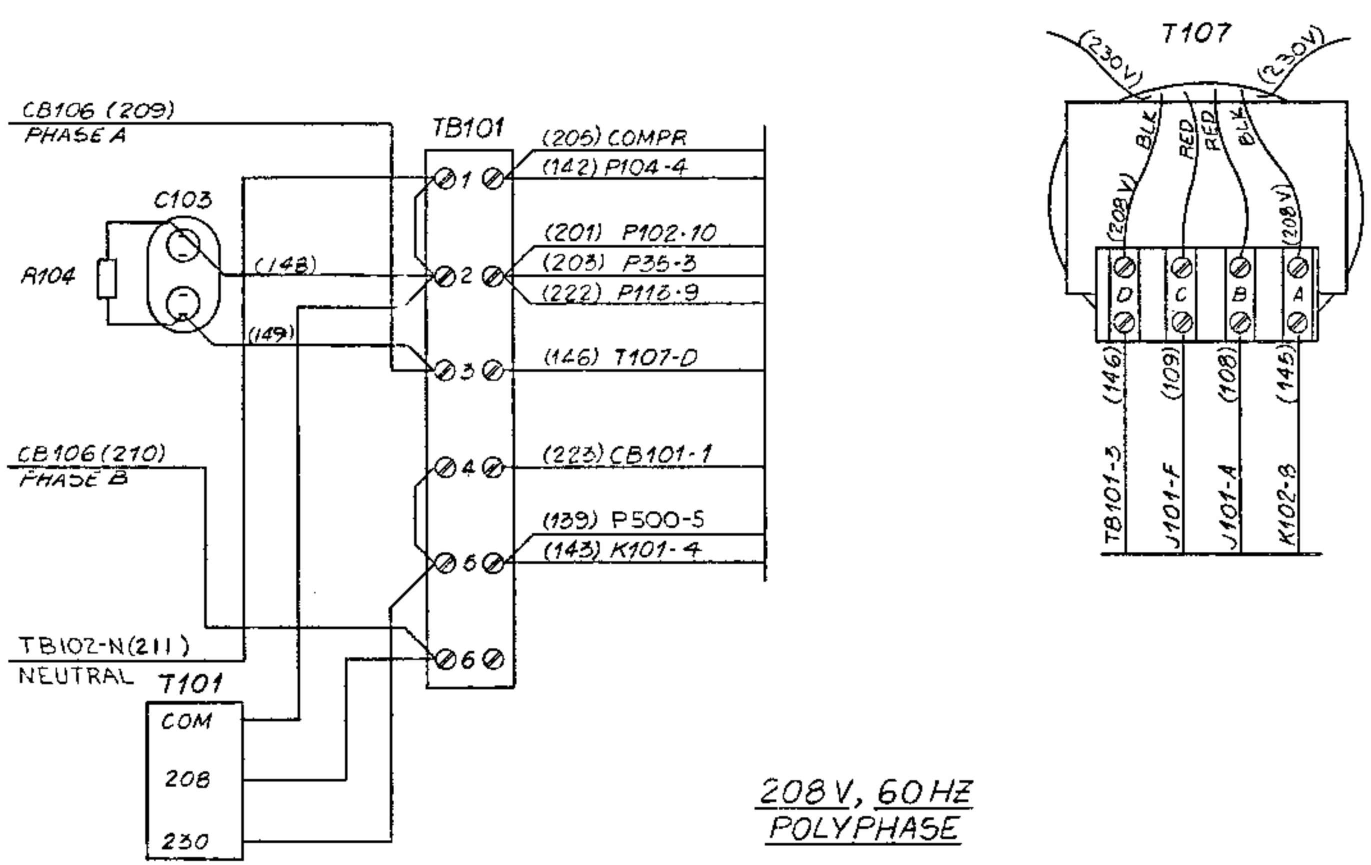


Figure 5-3. RC-5C Wiring System, (50808-4) Sheet 3 of 4





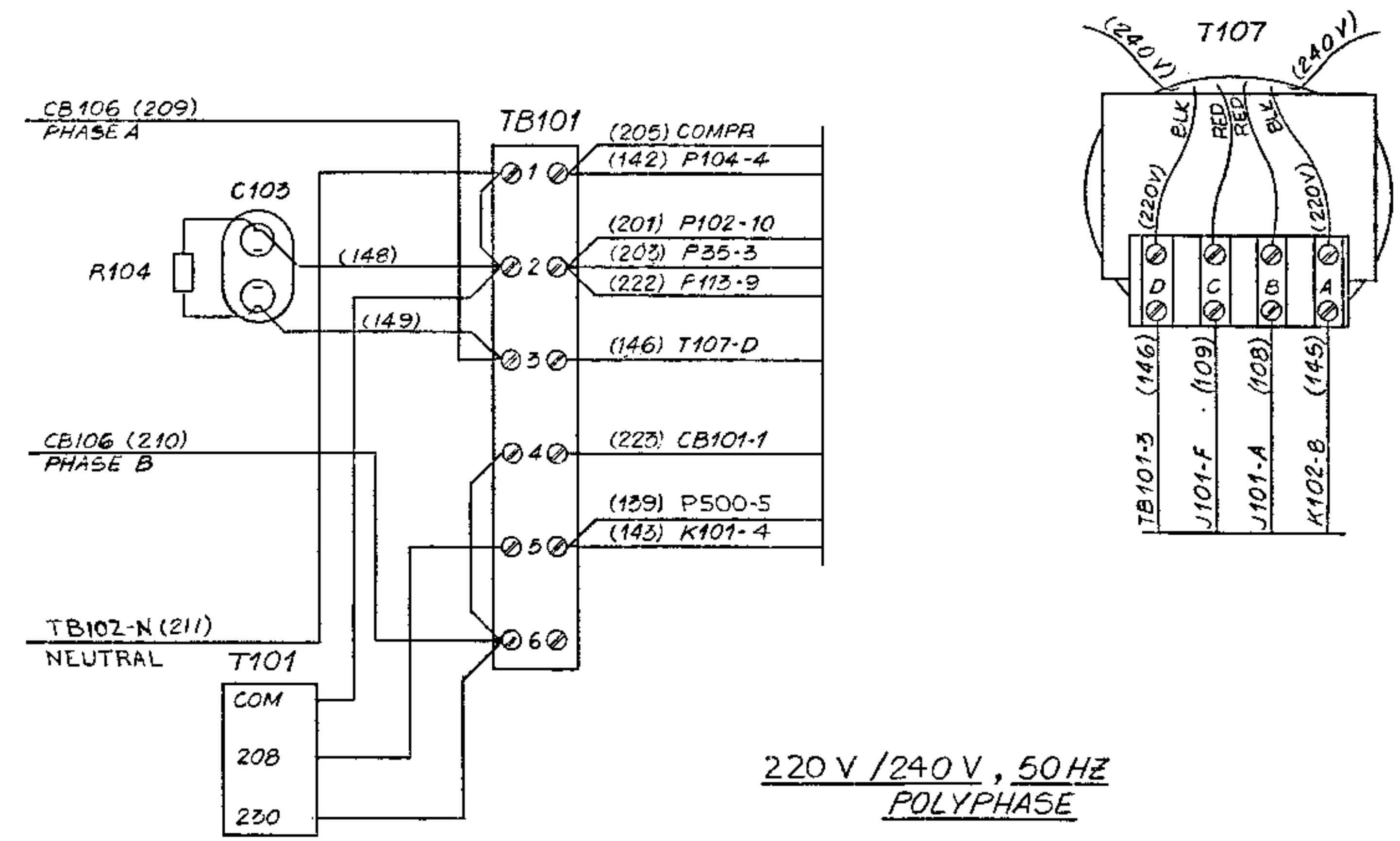


Figure 5-3. RC-5C Wiring System, (50808-4) Sheet 4 of 4

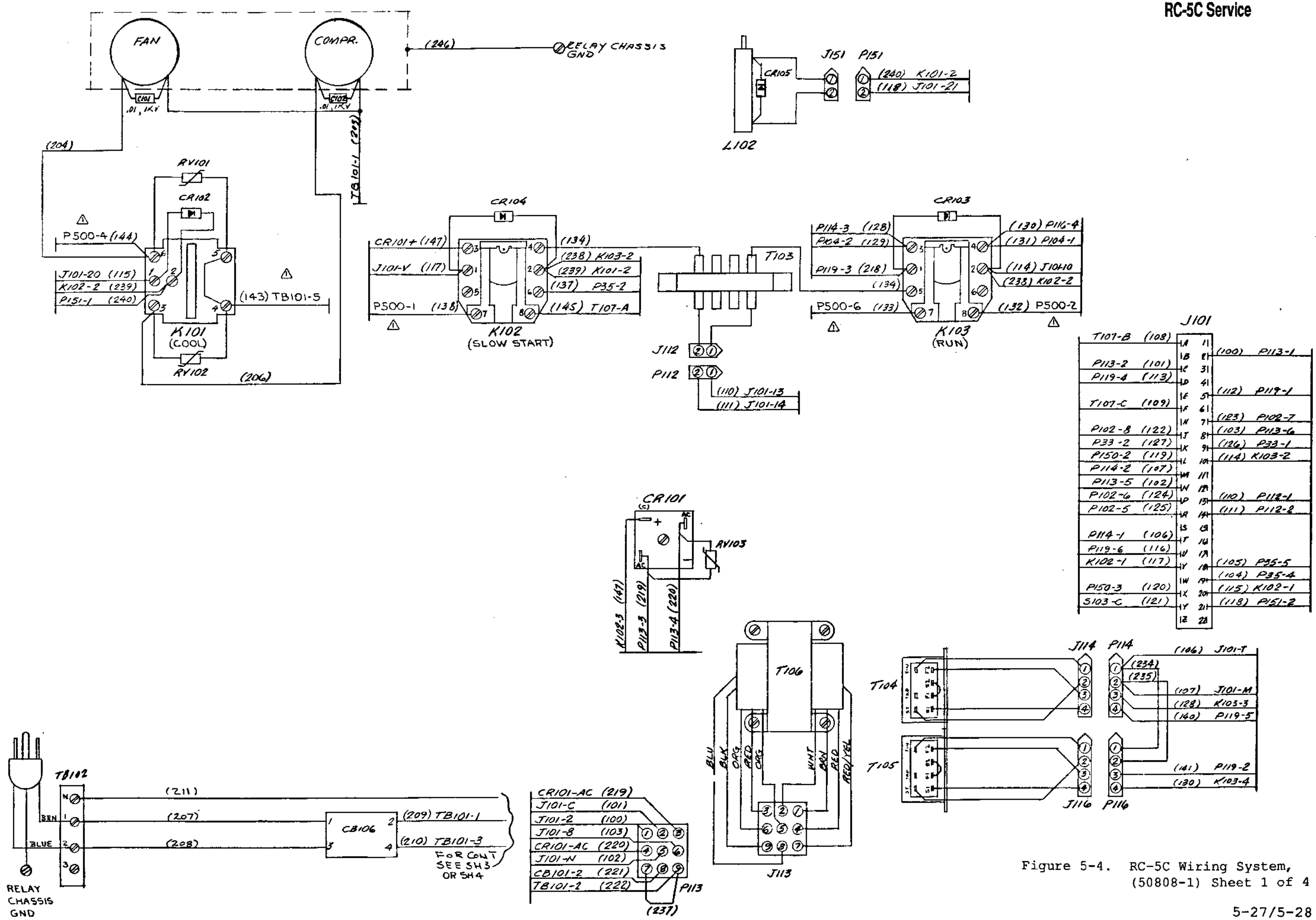


Figure 5-4. RC-5C Wiring System, (50808-1) Sheet 1 of 4

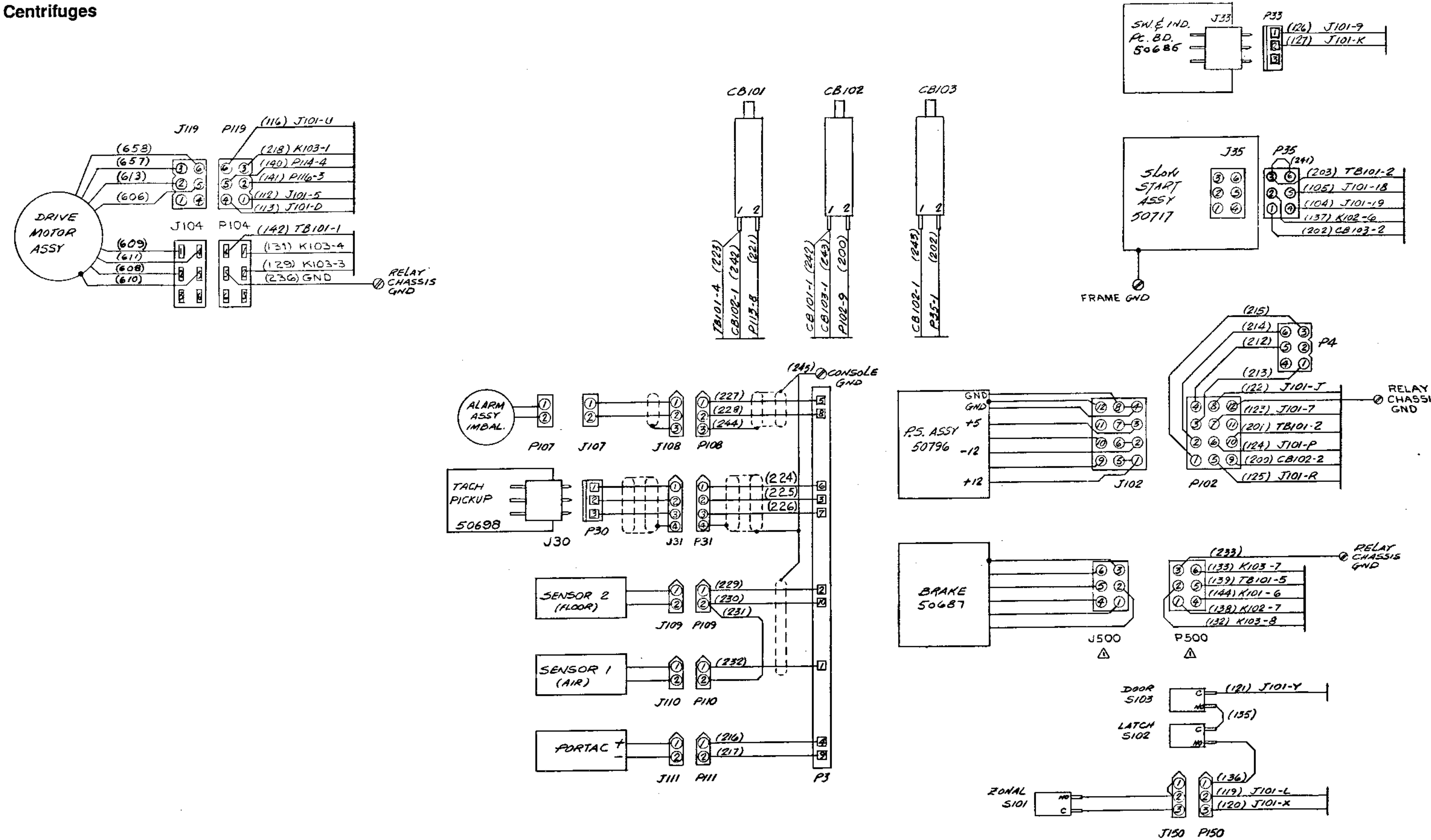
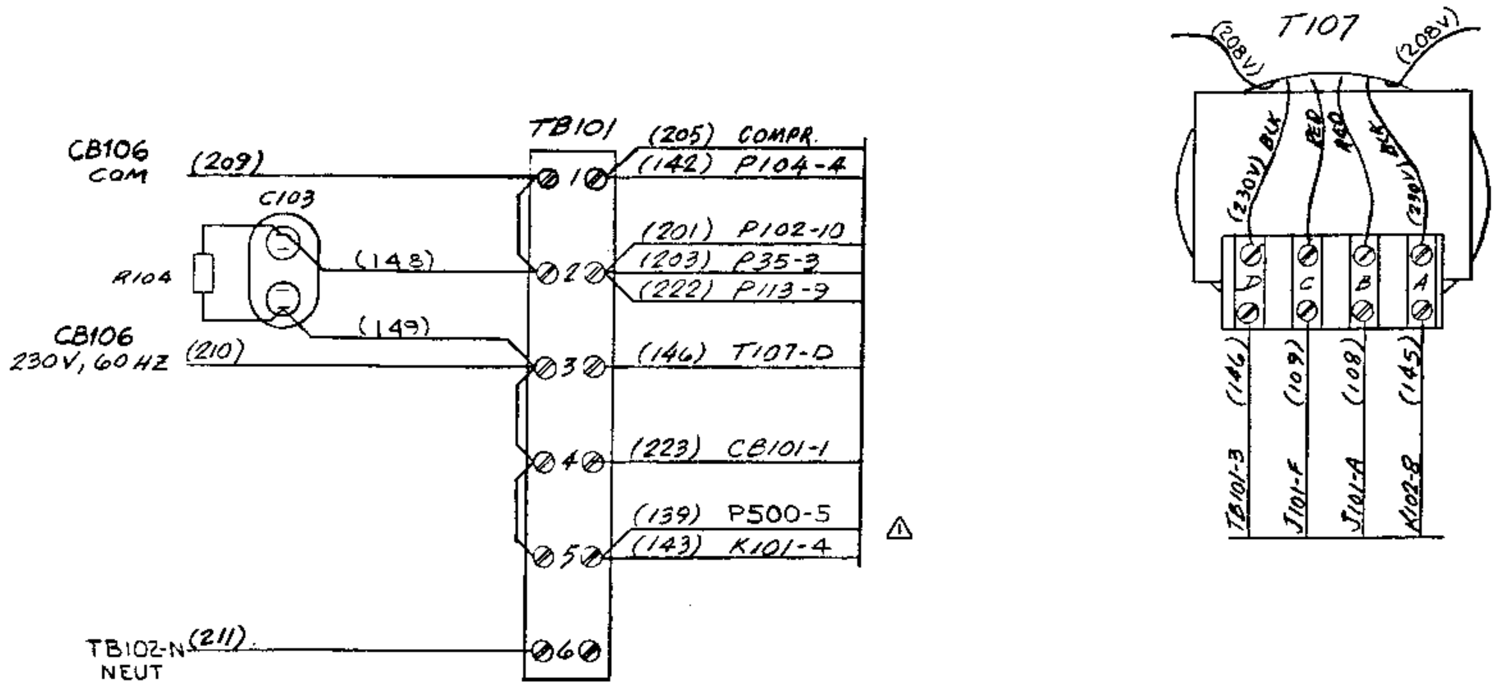
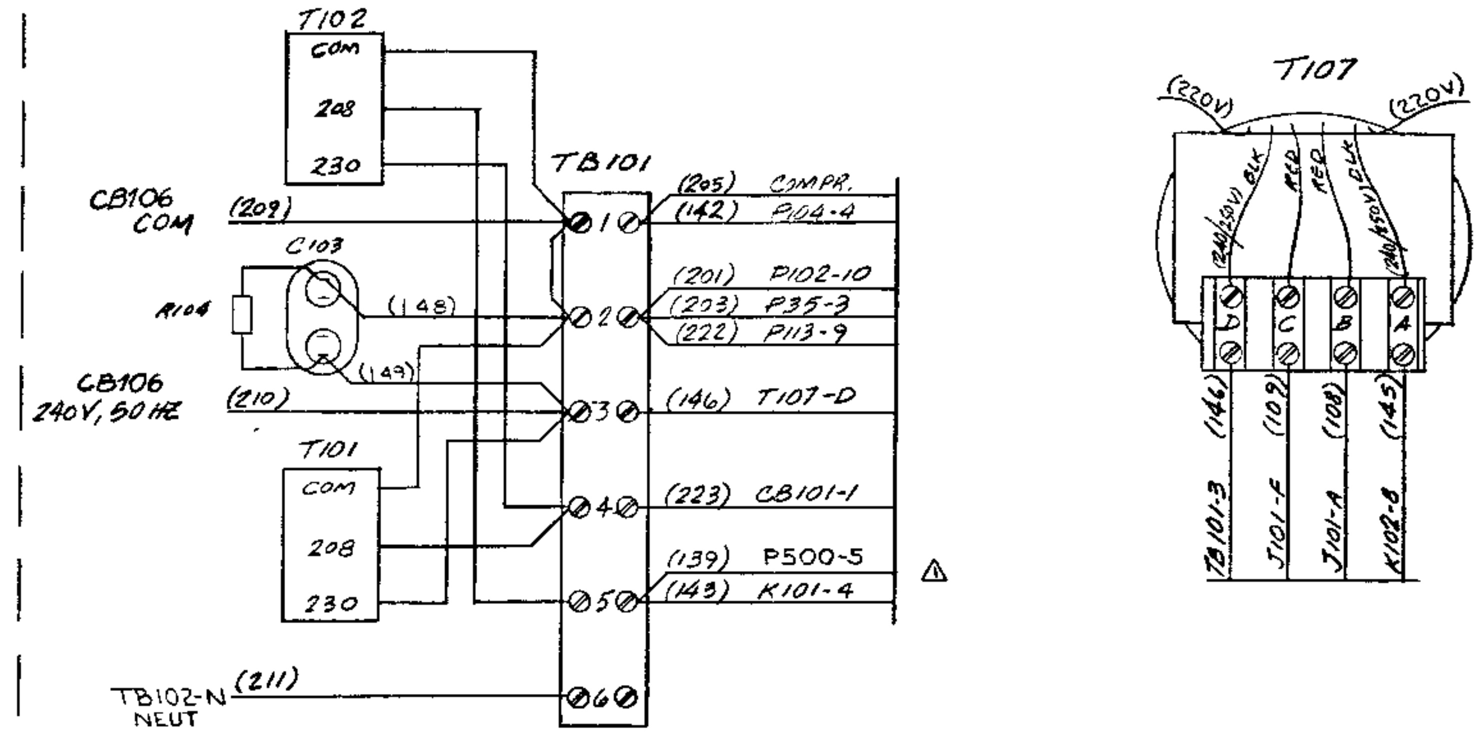


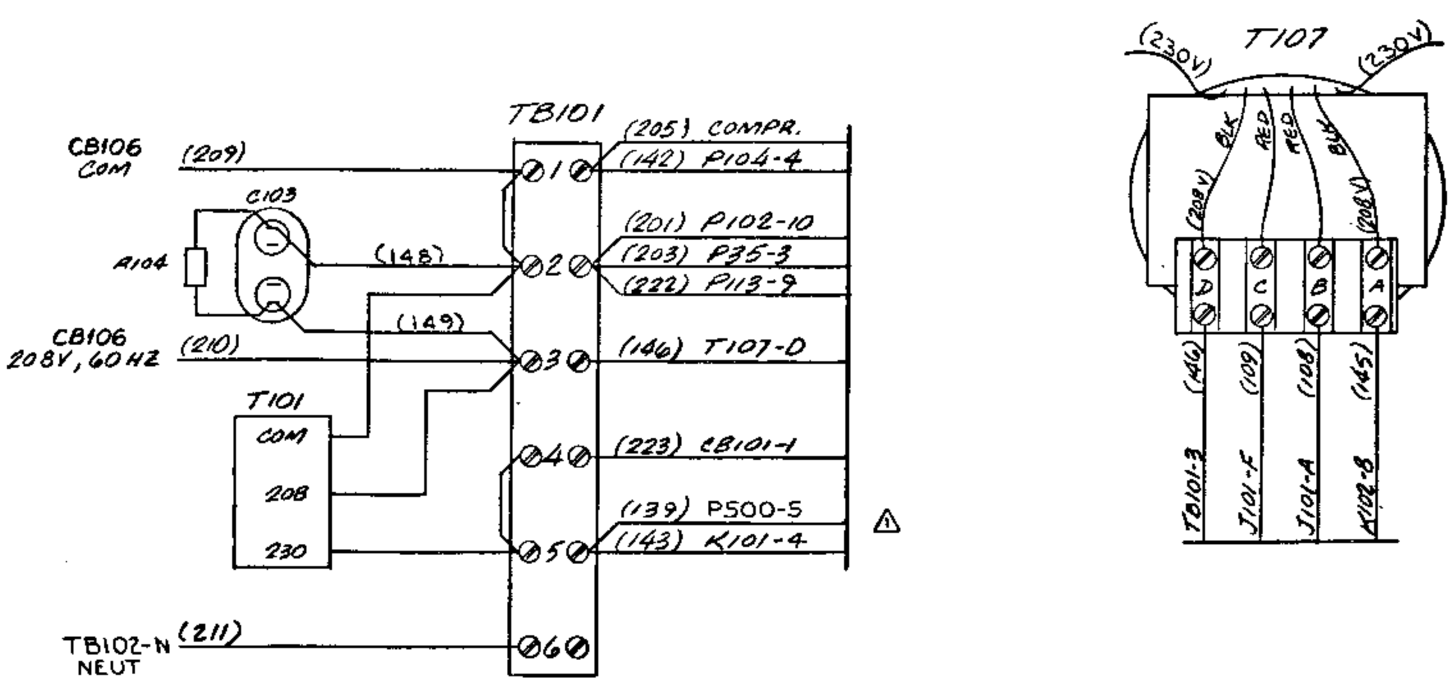
Figure 5-4. RC-5C Wiring System, (50808-1) Sheet 2 of 4



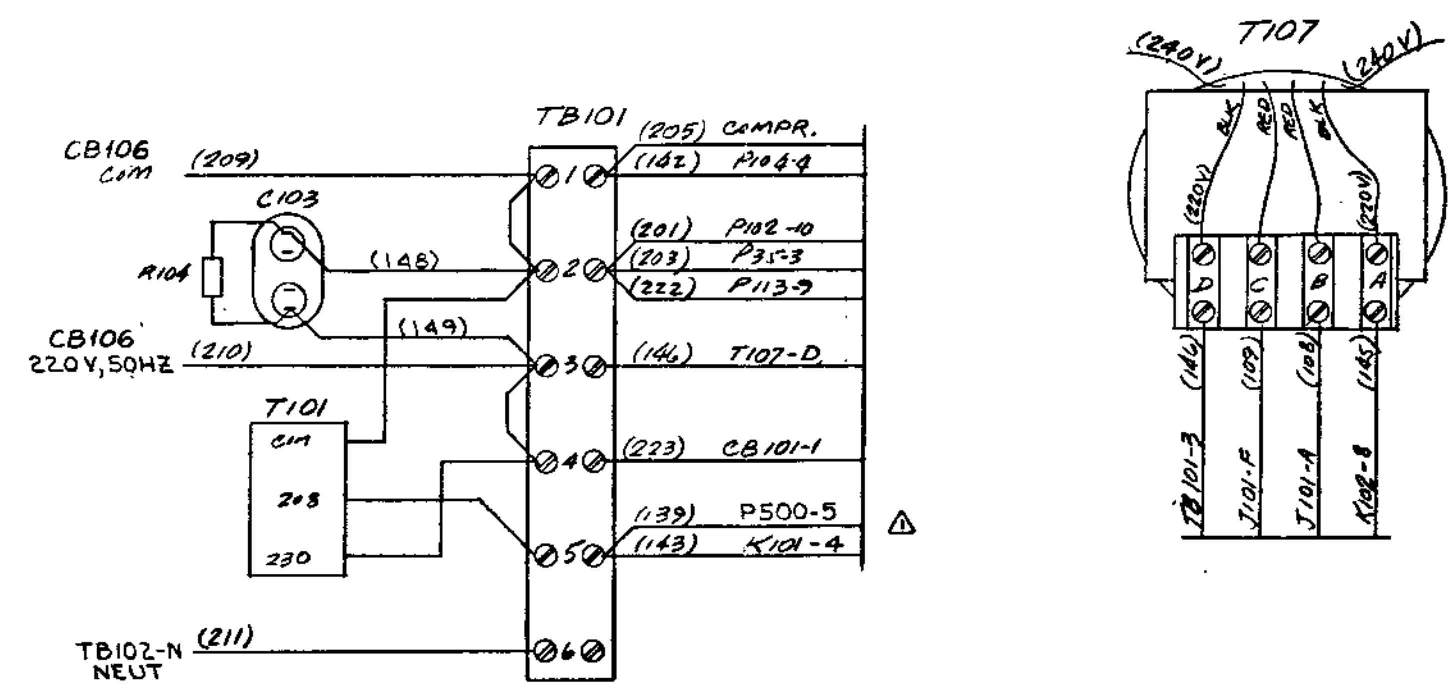
230 V, 60 HZ



240 V, 50 HZ

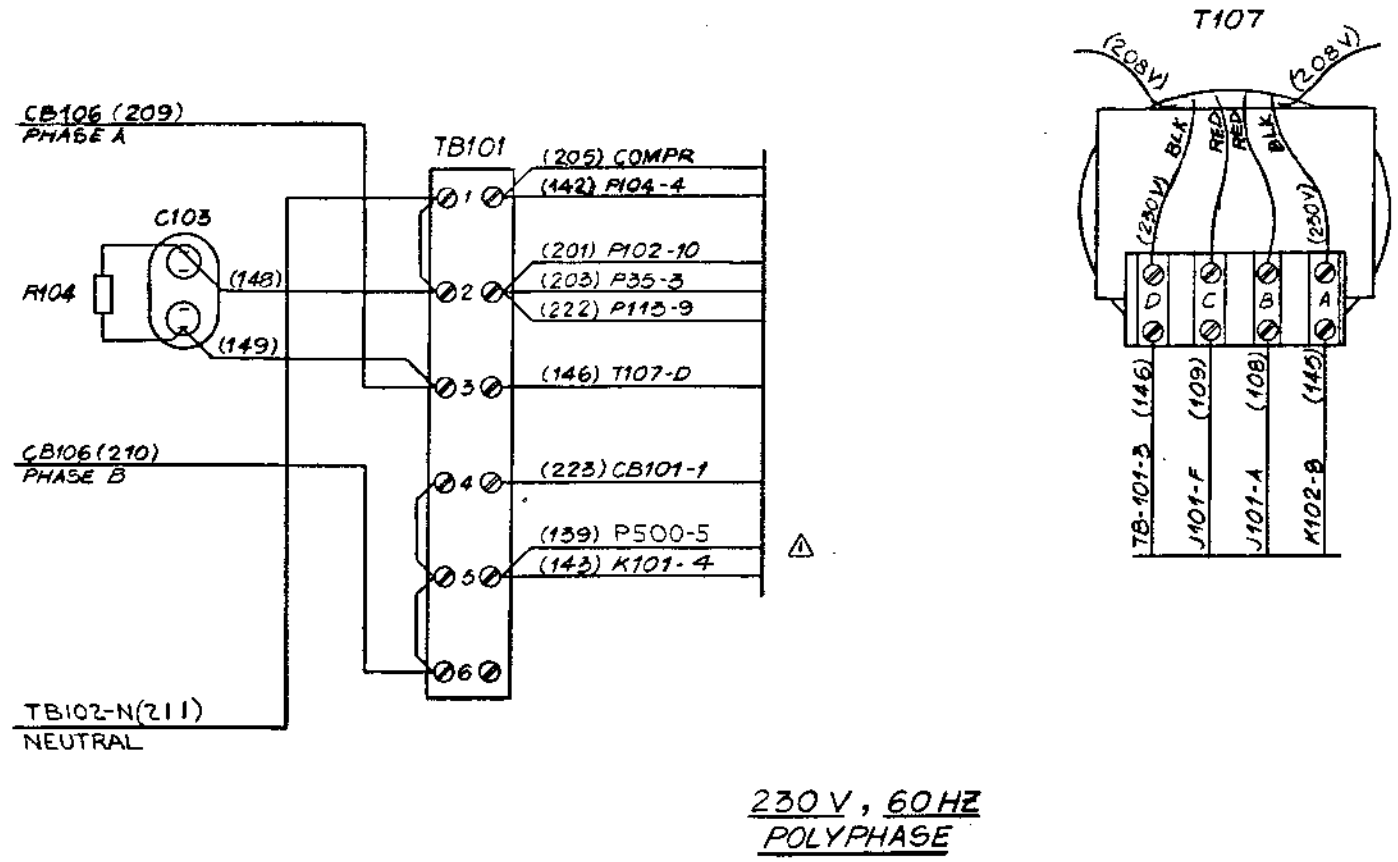


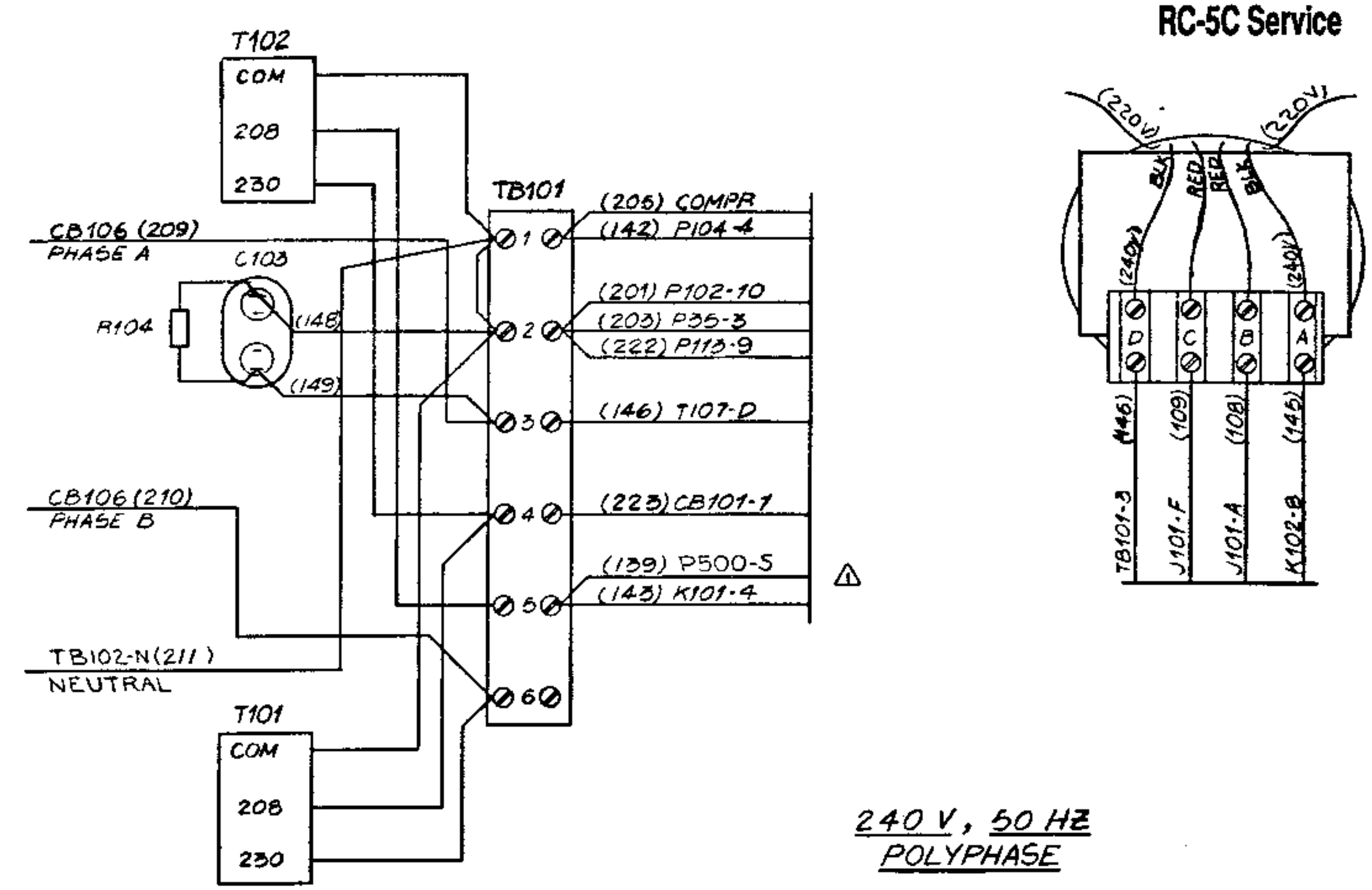
208 V, 60 HZ

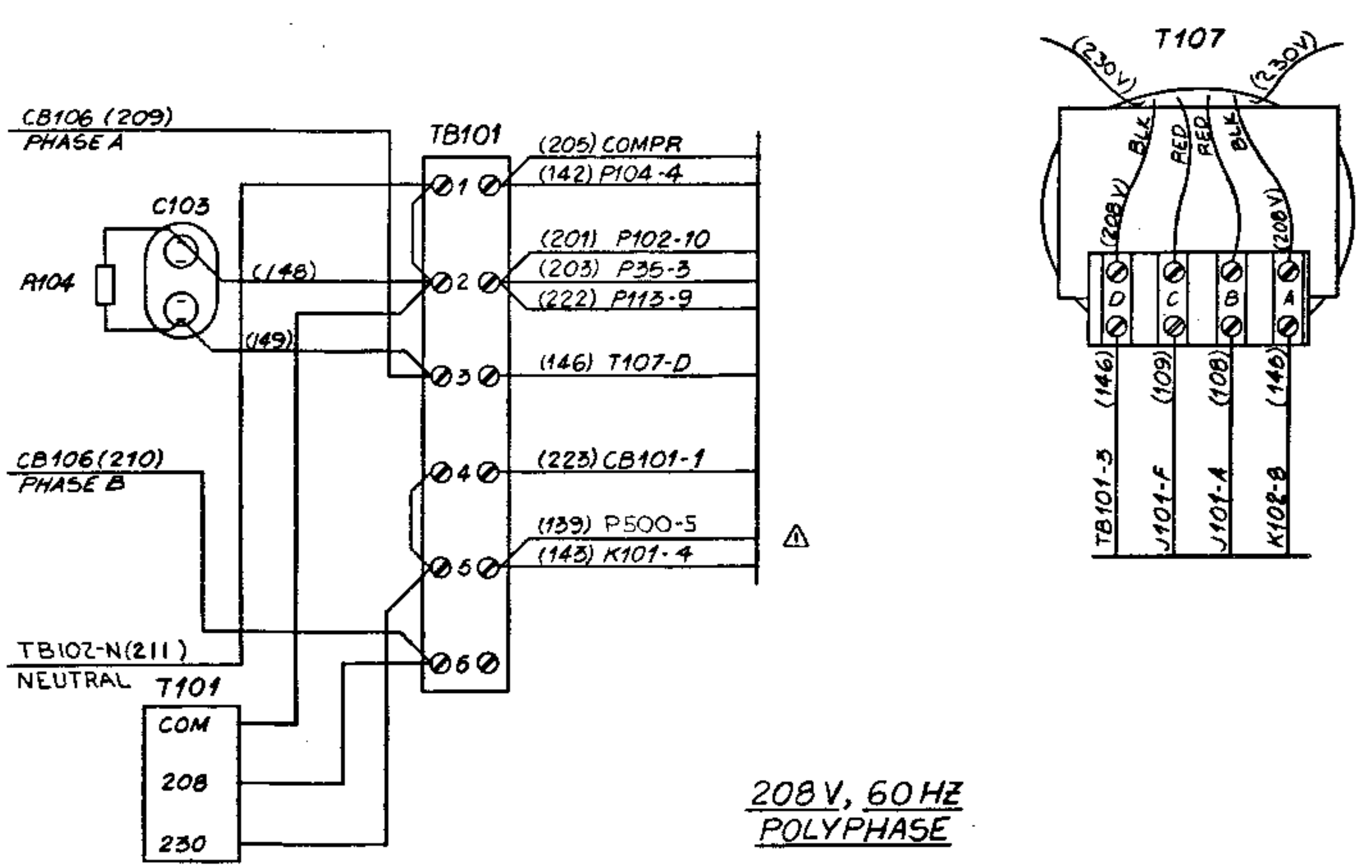


220 V, 50 HZ

Figure 5-4. RC-5C Wiring System, (50808-1) Sheet 3 of 4







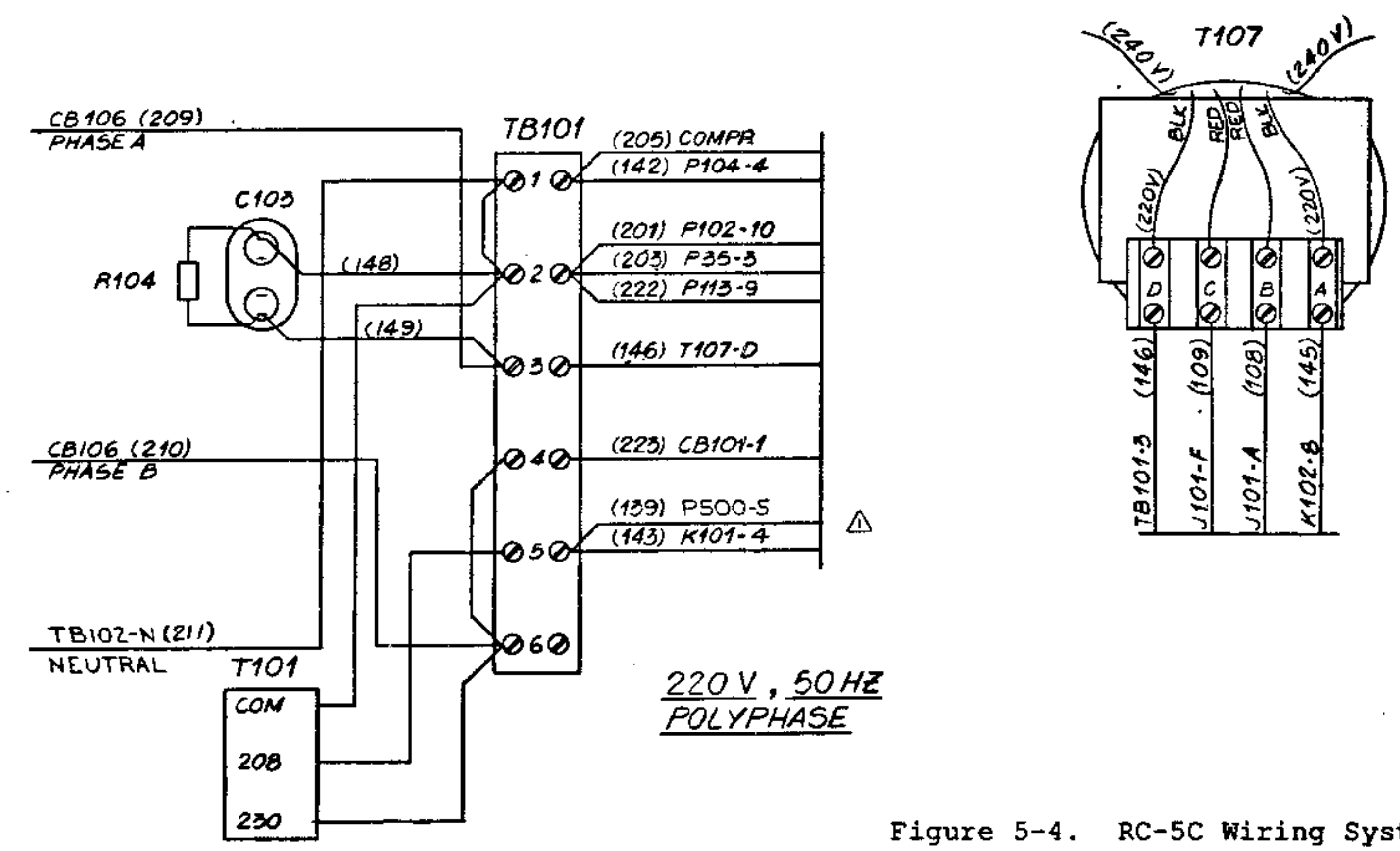
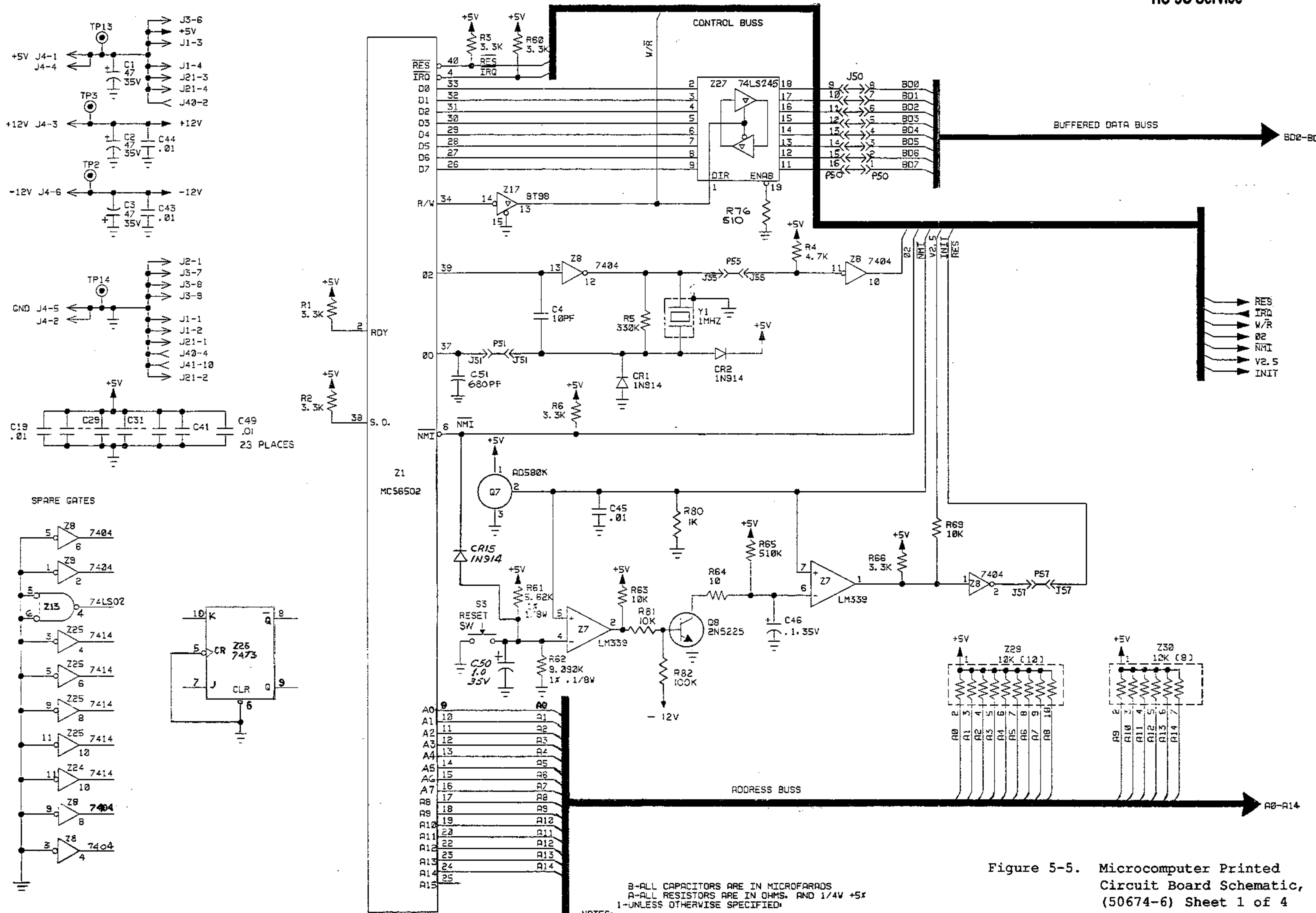


Figure 5-4. RC-5C Wiring System, (50808-1) Sheet 4 of 4



I.C. TABLE					
DESIG.	TYPE	+5V	GND	+12V	-12V
Z1	6502	8	1, 21	—	—
Z2	SPARE	24	12	—	—
Z3	2732	24	12	—	—
Z4	2732	24	12	—	—
Z5	6522	20	1	—	—
Z6	6523	20	1	—	—
Z7	LM339	3	12	—	—
Z8	7404	14	7	—	—
Z9	7404	14	7	—	—
Z10	2112	16	8	—	—
Z11	2112	16	8	—	—
Z12	7400	14	7	—	—
Z13	74LS02	14	7	—	—
Z14	74LS138	16	8	—	—
Z15	74LS139	16	8	—	—
Z16	8T97	16	8	—	—
Z17	8T98	16	8	—	—
Z18	8T97	16	8	—	—
Z19	AD7542	14	3, 12	—	—
Z20	CA3162	14	7	—	—
Z21	LM324	—	—	4	11
Z22	LM393	—	4	8	—
Z23	7407	14	7	—	—
Z24	7414	14	7	—	—
Z25	7414	14	7	—	—
Z26	7473	4	11	—	—
Z27	74LS245	20	10	—	—
Z28	74154	24	12	—	—

Figure 5-5. Microcomputer Printed Circuit Board Schematic, (50674-6) Sheet 1 of 4

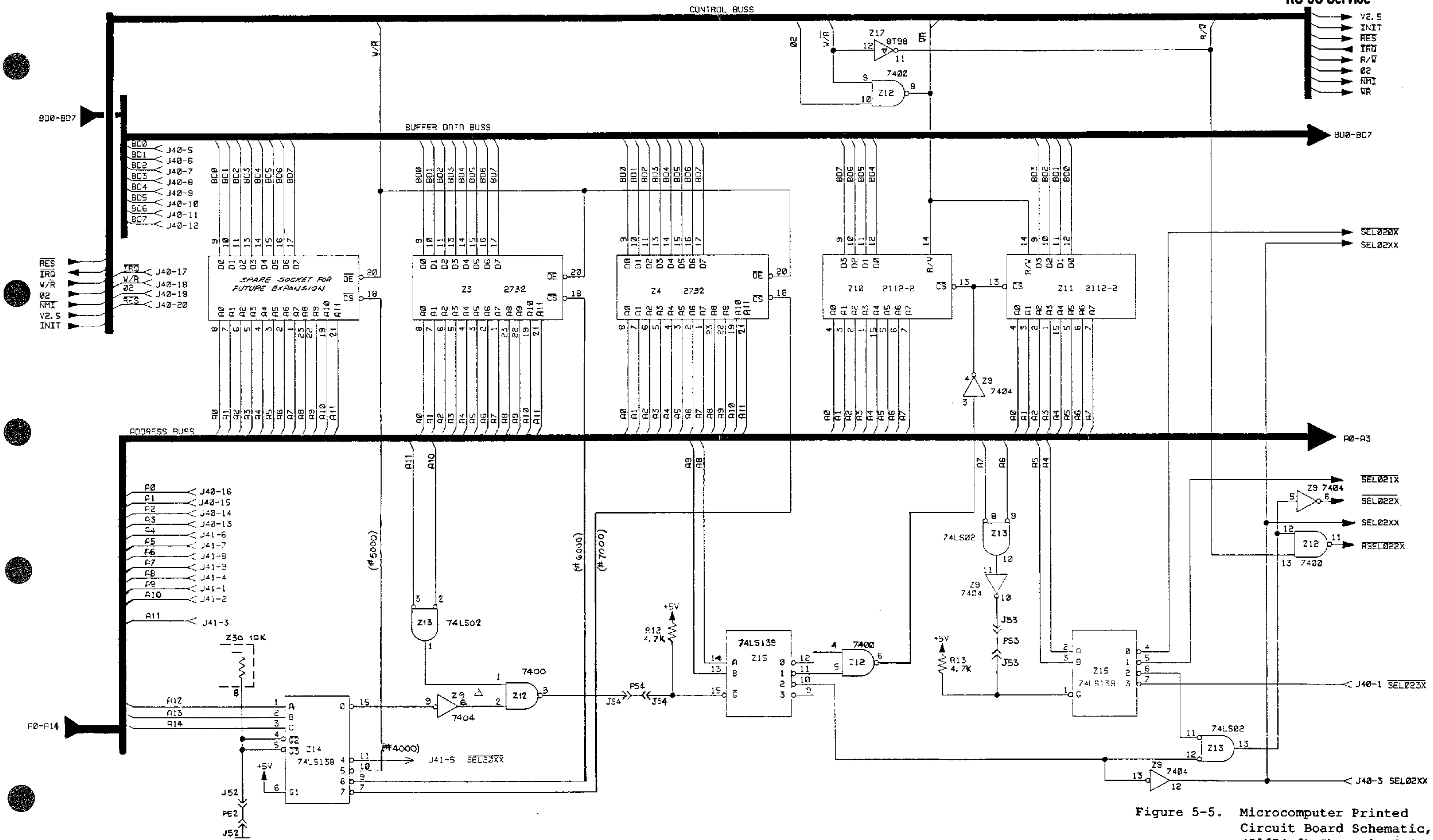


Figure 5-5. Microcomputer Printed Circuit Board Schematic, (50674-6) Sheet 2 of 4

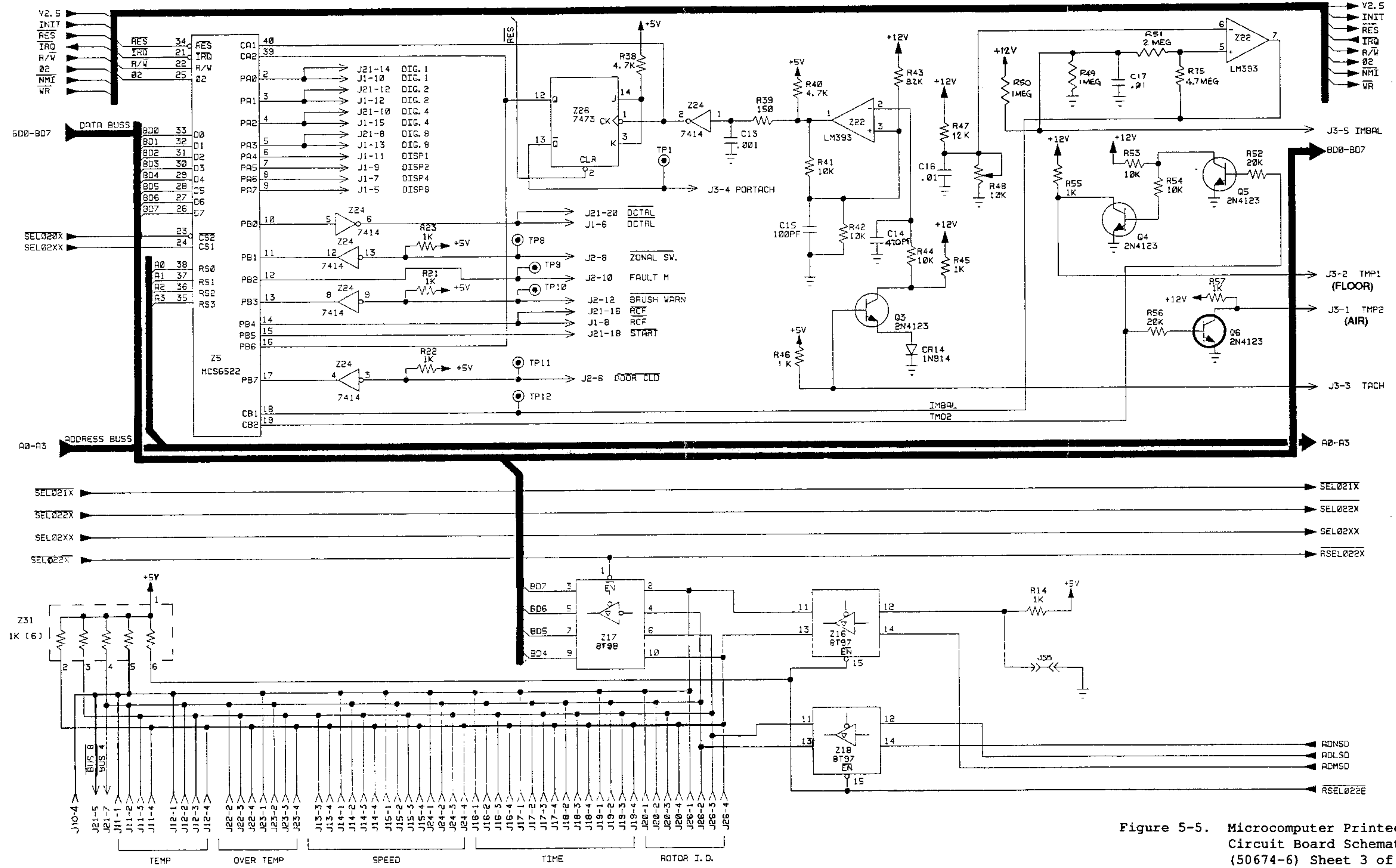


Figure 5-5. Microcomputer Printed Circuit Board Schematic, (50674-6) Sheet 3 of 4

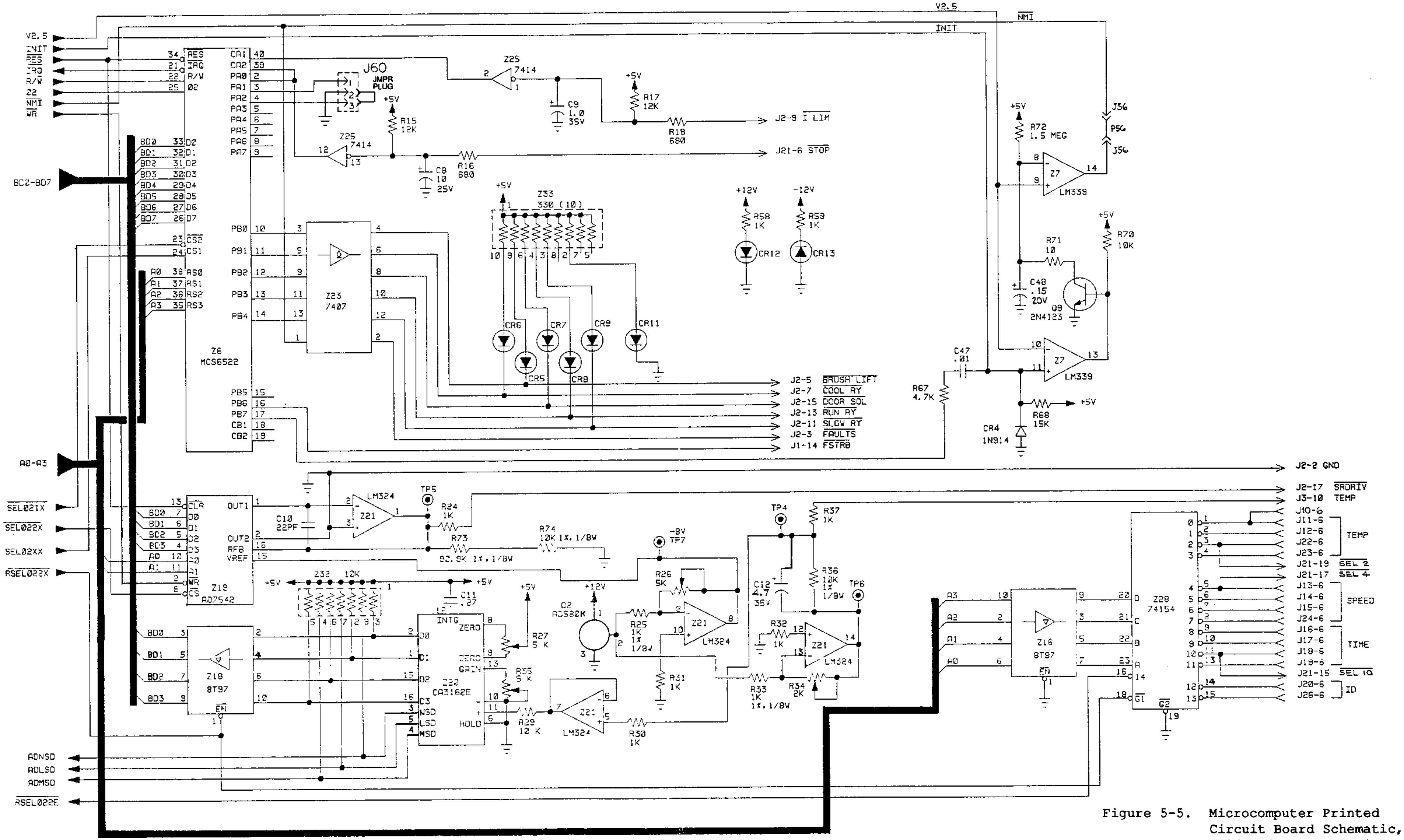


Figure 5-5. Microcomputer Printed Circuit Board Schematic, (50674-6) Sheet 4 of 4

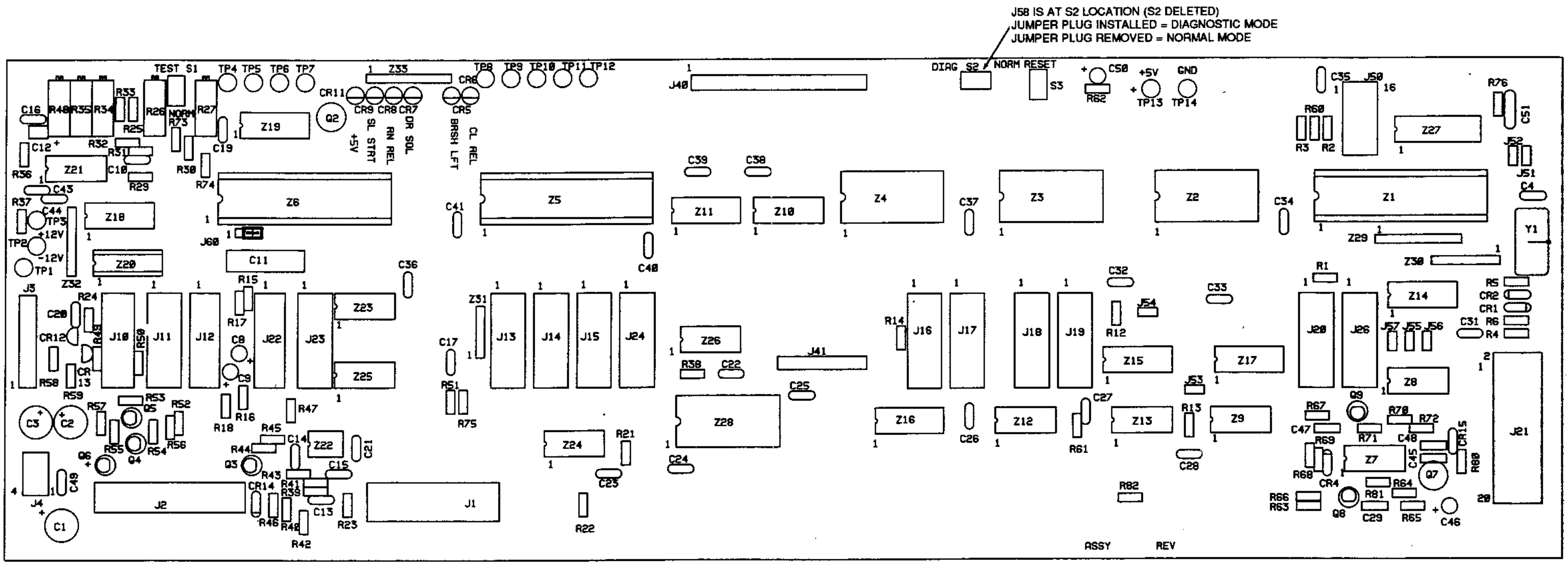


Figure 5-6. Microcomputer Printed Circuit Board Component Locations, (50673-3)

Table 5-1. Microcomputer Board Component Identification
(Refer to Figure 5-6)

Component	Description	Manufacturer Order Number
R1,R2,R3, R6,R60,R66	Resistor, Fixed, Carbon Compound, 3.3K Ohms, 1/4W, ±5%	*
R4,R12,R13, R38,R40,R67	Resistor, Fixed, Carbon Compound, 4.7K Ohms, 1/4W, ±5%	*
R5	Resistor, Fixed, Carbon Compound, 330K Ohms, 1/4W, ±5%	*
R14,R21,R22, R23,R24,R30, R31,R32,R37, R45,R55,R57, R58,R59,R80	Resistor, Fixed, Carbon Compound, 1K Ohms, 1/4W, ±5%	*
R15,R17,R47	Resistor, Fixed, Carbon Compound, 12K Ohms, 1/4W, ±5%	*
R16,R18	Resistor, Fixed, Carbon Compound, 680 Ohms, 1/4W, ±5%	*
R25,R33	Resistor, Metal Film, 1K Ohms, 1/8W, ±1%	#RN55D1001F
R26,R27,R35	Resistor, Variable, Cermet, P.C. Type, 5K Ohms	BOURNS #3009P-1-502
R29,R41,R42, R44,R53,R54, R63,R69,R70, R81	Resistor, Fixed, Carbon Compound, 10K Ohms, 1/4W, ±5%	*
R34	Resistor, Variable, Cermet, P.C. Type, 2K Ohms	BOURNS #3009P-1-202
R36,R74	Resistor, Metal Film, 10k Ohms, 1/8W, ±1%	ALLEN BRADLEY #CC1002E
R39	Resistor, Fixed, Carbon Compound, 150 Ohms, 1/4W, ±5%	*
R43	Resistor, Carbon Compound, 8.2K Ohms, 1/4W, ±5%	*
R46	Resistor, Fixed, Carbon Compound, 1K Ohms, 1/4W, ±5%	*
R47	Resistor, Fixed, Carbon Compound, 47K Ohms, 1/4W, ±5%	*

*Standard component available through most suppliers.

Table 5-1. Microcomputer Board Component Identification (Refer to Figure 5-6), continued

Component	Description	Manufacturer Order Number
R48	Resistor, Variable, Cermet, P.C. Type, 10K Ohms	BOURNS #3009P-1-103
R49,R50	Resistor, Fixed, Carbon Compound, 1 MEG Ohms, 1/4W, ±5%	*
R51	Resistor, Fixed, Carbon Compound, 2 MEG Ohms, 1/4W, ±5%	*
R52,R56	Resistor, Fixed, Carbon Compound, 20K Ohms, 1/4W, ±5%	*
R61	Resistor, Metal Film, 5.62K Ohms, 1/8W, ±1%	DALE #CMF-55-T1-5.6K-1%
R62	Resistor, Metal Film, 9.09K Ohms, 1/8W, ±1%	DALE #CMF-55-T1-9.09K-1%
R64,R71	Resistor, Fixed, Carbon Compound, 10 Ohms, 1/4W, ±5%	*
R65	Resistor, Fixed, Carbon Compound, 510K Ohms, 1/4W, ±5%	*
R68	Resistor, Fixed, Carbon Compound, 15K Ohms, 1/4W, ±5%	*
R72	Resistor, Fixed, Carbon Compound, 1.5 MEG Ohms, 1/4W, ±5%	*
R73	Resistor, Metal Film, 90.9K Ohms, 1/8W, ±5%	DALE #CMF-55-T1-90.9K-1%
R75	Resistor, Fixed, Carbon Compound, 4.7 MEG Ohms, 1/4W, ±5%	*
R76	Resistor, Carbon Compound, 510 Ohms, 1/4W, ±5%	*

*Standard component available through most suppliers.

Table 5-1. Microcomputer Board Component Identification (Refer to Figure 5-6), continued

Component	Description	Manufacturer Order Number
R82	Resistor, Carbon Compound, 100K Ohms, 1/4W, 5%	*
TP1,TP2,TP3, TP4,TP5,TP6, TP7,TP8,TP9, TP10,TP11, TP12,TP13, TP14	Terminal, Swage, 2 Turrett, Brass, Silver Plated	H. H. SMITH P/N 2018C
Q3,Q4,Q5, Q6,Q9	Transistor, NPN	MOTOROLA #2N4123
Q2,Q7	Integrated Circuit, Voltage Ref., Low Drift, 2.5 Volts	ANALOG #AD580K
Q8	Transistor, NPN, Silicon	MOTORAL #2N5225
CR1,CR2,CR4 CR14,CR15	Diode, Silicon, Switching	FAIRCHILD #IN914
CR5,CR6,CR7, CR8,CR9,CR11, CR12,CR13	Diode, Light Emitting, Red	GENERAL INSTRUM #MV5055
C1,C2,C3	Capacitor, Electrolytic, Aluminum, 47 MFD, 35 WVDC	SPRAGUE #503D476F0 35NB
C4	Capacitor, Ceramic Disc, 10PF, 1000 WVDC	*
C8	Capacitor, Electrolytic, Aluminum, 10 MFD, 25 WVDC	ILLINOIS #106R1R025M
C9,C50	Capacitor, Fixed, Tantalum, 1.0 MFD, 35 WVDC	SPRAGUE #196D105X90 35HAI
C10	Capacitor, Ceramic Molded, 22 PF, 200 WVDC	SPRAGUE #CKR05BX220K1
C11	Capacitor, Filmite "E", Pacer, 0.27 MFD, 80 WVDC	SPRAGUE #192P2749R8
C12	Capacitor, Fixed Tantalum, 4.7 MFD, 35 WVDC	MALLORY #TDC475M035BS

*Standard component available through most suppliers.

Table 5-1. Microcomputer Board Component Identification (Refer to Figure 5-6), continued

Component	Description	Manufacturer Order Number
C13	Capacitor, Ceramic Molded, 1000 PF, 200 WVDC	SPRAGUE #CKR05BX102KL
C14	Capacitor, Ceramic Molded, 470 PF, 200 WVDC	SPRAGUE #CKR0513X 471KL
C15	Capacitor, Ceramic Molded, 100 PF, 200 WVDC	SPRAGUE #CKR05BX101KL
C16,C17,C19, C20,C21,C22, C23,C24,C25, C26,C27,C28, C29,C31,C32, C33,C34,C35, C36,C37,C38, C39,C40,C41, C43,C44,C45, C47	Capacitor, Ceramic Molded, .01 MFD, 100 WVDC	SPRAGUE #CKR05BX103ML
C46	Capacitor, Fixed Tantalum, 0.1 MFD, 35 WVDC	SPRAGUE #196D104X90 35HAI
C48	Capacitor, Fixed Tantalum, 0.15 MFD, 20 VDC	MALLORY #TDC154M020AS
C51	Capacitor, Ceramic Disc, 680 PF, 1000 WVDC	SPRAGUE #C023B102E 681M
Y1	Crystal, 1 MHZ	CLARK CRYSTAL P/N CL-19P
S3	Switch, SPST, Mini-Pushbutton, P.C. Type, 0.4 VA Max	ALCO #TPB11CG-PC2
Z1	Integrated Circuit, Microprocessor	MOS TECHNOL INC.#MCS 6502
Z2	Memory, Programmed, 2800-RC5C	*
Z3	Memory, Programmed, 3000-RC5C	*
Z4	Memory, Programmed, 3800-RC5C	*
Z5,Z6	Integrated Circuit, Versatile, Interface Adapter	MOS TECHNOLO INC.#MCS 6522

*Standard component available through most suppliers.

Table 5-1. Microcomputer Board Component Identification (Refer to Figure 5-6), continued

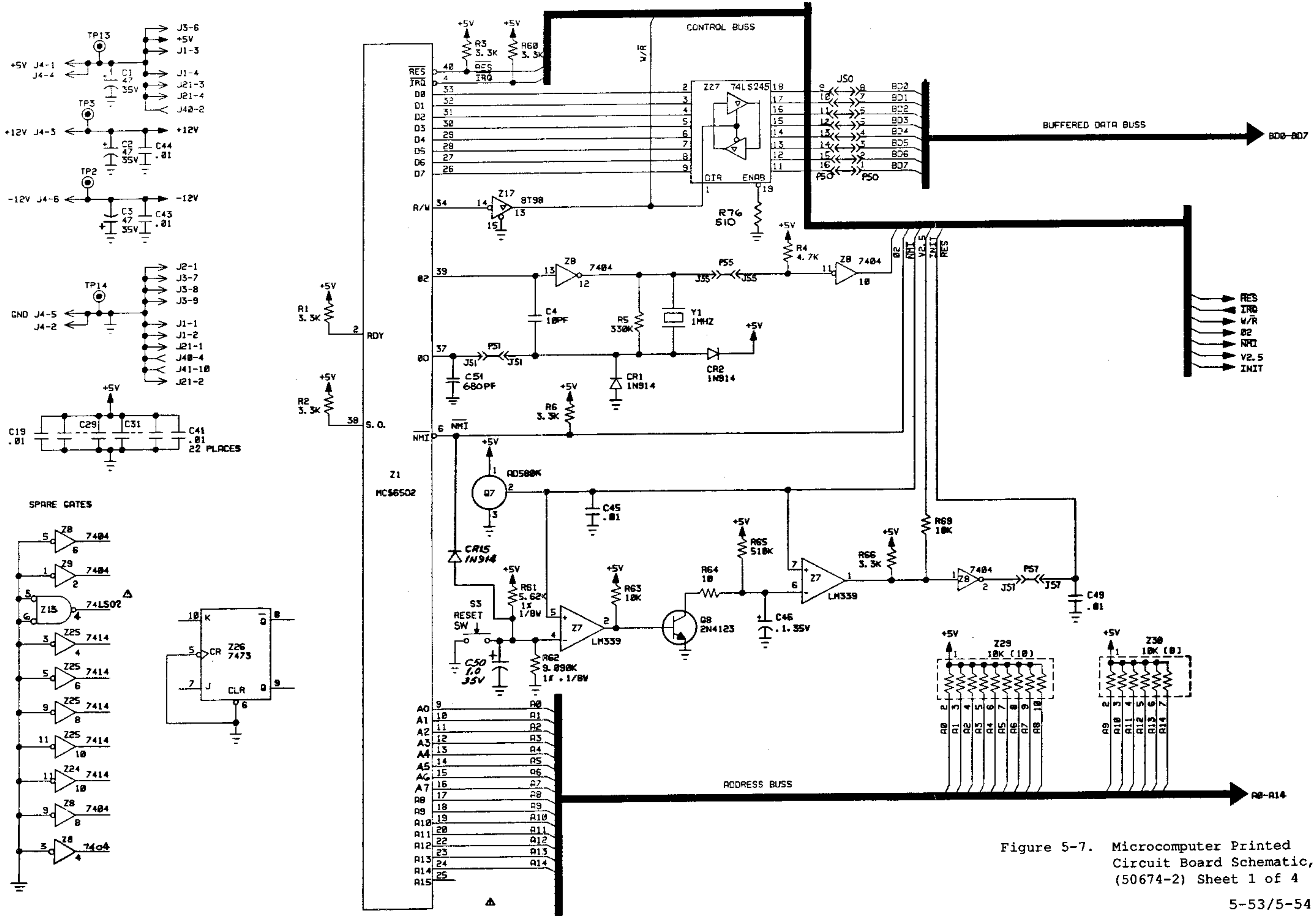
Component	Description	Manufacturer Order Number
Z7	Integrated Circuit, Analog, Quad Comparator	NATIONAL #LM339N
Z8,Z9	Integrated Circuit, Digital, Hex Inverter, T0-116	TEXAS INSTR. #SN7404N
Z10,Z11	Integrated Circuit, 1024-Bit Static MOS RAM (256 X 4)	SIGNETICS #2112-2
Z12	Integrated Circuit, Quad 2, Input Positive, NAND GATE, 14 Pin	TEXAS INSTR. #5N7400N
Z13	Integrated Circuit, Quad 2, Input Positive, NOR GATE, 14 Pin DIP	TEXAS INSTR. #SN74LS02N
Z14	Integrated Circuit, Decoder/ Demultiplexer, 16 Pin DIP	TEXAS INSTR. #SN74LS138N
Z15	Integrated Circuit, Decoder/ Demultiplexer, 16 Pin DIP	TEXAS INSTR. #SN74LS139N
Z16,Z18	Integrated Circuit, High Speed, Hex Tri-State Buffer	SIGNETICS #8T97
Z17	Integrated Circuit, High Speed, Hex Tri-State Inverter	SIGNETICS #8T98
Z19	Integrated Circuit, 12-Bit, CMOS Multiplying DAC	ANALOG DEV. #AD7542JN
Z20	Integrated Circuit, Analog/ Digital Converter, Dual-In-Line	RCA #CA3162E
Z21	Integrated Circuit, Low Power Quad Amplifier	NAT'L SEMI. #LM324N
Z22	Integrated Circuit, Dual Differential Comparator	TEXAS INSTR. #LM393
Z23	Integrated Circuit, High Voltage Output, Hex BFR/DRVR W/Open Coll	TEXAS INSTR. #SN7407
Z24,Z25	Integrated Circuit, Hex Schmitt-Trigger Inverter	TEXAS INSTR. #SN7414N

Table 5-1. Microcomputer Board Component Identification (Refer to Figure 5-6), continued

Component	Description	Manufacturer Order Number
Z26	Integrated Circuit, Dual J-K, Master Slave Flip-Flop, 14 Pin DIP	TEXAS INSTRU. #SN7473N
Z27	Integrated Circuit, Octal Bustransceiver, 20 Pin DIP	TEXAS INSTRU. #SN74L5245
Z28	Integrated Circuit, 4 Line to 6 Line, Decoder/ Demultiplexers	TEXAS INSTRU. #SN74154
Z29	Resistor, Network, 10 Pin, SIP, 10K, 1.25W	BOURNS #4310R-101-103J
Z30,Z32	Resistor, Network, 8 Pin, SIP, 10K, 1.0W	BOURNS #4308R-101-103J
Z31	Resistor, Network, 6 Pin, SIP, 1.0K, .75W	BOURNS #4306R-101-102J
Z33	Resistor, Network, 10 Pin, SIP, 330 Ohms, 1.25W	BOURNS #4310R-101-331J
J1	Connector, P.C., RT. Angle, Low Profile, EJCTR, HDR, 16 Posn	T&B ANSLEY #609-1617ES
J2,J21	Connector, P.C., RT. Angle, Low Profile, EJCTR, HDR, 20 Posn	T&B ANSLEY #609-2017ES
J3	Connector, Polarizing & Locking Wafer, 10 Contacts	MOLEX #22-27-2101
J4	Connector, Plug, Elec, 6 Posn	MOLEX #10-18-1061
J10,J11,J12, J13,J14,J15, J16,J17,J18, J19,J20,J22, J23,J24,J26	Connector, P.C., Card Edge, 6 Posn	EDAC #306-006-521-101
J40	Connector, P.C., Top Entry, 20 Posn	MOLEX #22-02-2201

Table 5-1. Microcomputer Board Component Identification (Refer to Figure 5-6), continued

Component	Description	Manufacturer Order Number
J41	Connector, P.C., Top Entry, 10 Posn	MOLEX #22-02-2101
J50	Socket, I.C., Low Profile, 16 Pin	TEXAS INSTRU. PN C84-16-02
J51,J52,J53, J54,J55,J56, J57	Connector, Square Pin, Straight Wafer, 2 Contact	MOLEX #22-03-2021
J58,J60	Connector, P.C., Vertical, Center Wafer, 3 POSN, Male	MOLEX #22-03-2031
P50	Shunt, Programmable, Dual-In-Line Package (DIP), STD. Pressure	AMP #435704-8
P51,P52,P53, P54,P55,P56, P57,P58,P60	Plug, Interconnection, 2 Posn	BERG #65474-001



I.C. TABLE					
DESIG.	TYPE	+5V	GND	+12V	-12V
Z1	6502	8	1,21	—	—
Z2	SPARE	24	12	—	—
Z3	2732	24	12	—	—
Z4	2732	24	12	—	—
Z5	6522	20	1	—	—
Z6	6522	20	1	—	—
Z7	LM339	3	12	—	—
Z8	7404	14	7	—	—
Z9	7404	14	7	—	—
Z10	2112	16	8	—	—
Z11	2112	16	8	—	—
Z12	7400	14	7	—	—
Z13	74LS02	14	7	—	—
Z14	74LS138	16	8	—	—
Z15	74LS139	16	8	—	—
Z16	8T97	16	8	—	—
Z17	8T98	16	8	—	—
Z18	8T97	16	8	—	—
Z19	AD7542	14	3,12	—	—
Z20	CA3162	14	7	—	—
Z21	LM324	—	—	4	11
Z22	LM393	—	4	8	—
Z23	7407	14	7	—	—
Z24	7414	14	7	—	—
Z25	7414	14	7	—	—
Z26	7473	4	11	—	—
Z27	74LS245	20	10	—	—
Z28	74154	24	12	—	—

Figure 5-7. Microcomputer Printed Circuit Board Schematic, (50674-2) Sheet 1 of 4

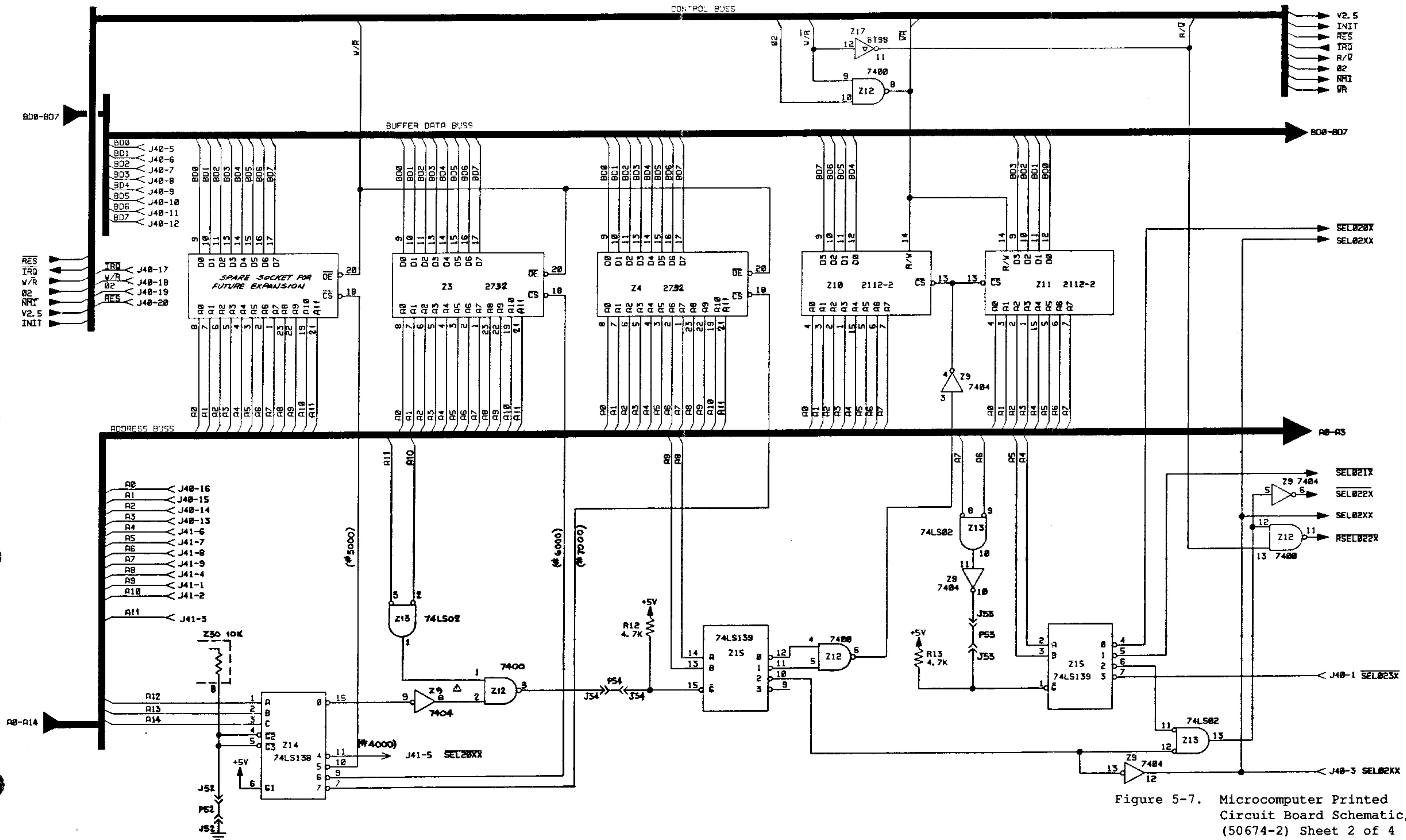


Figure 5-7. Microcomputer Printed Circuit Board Schematic, (50674-2) Sheet 2 of 4

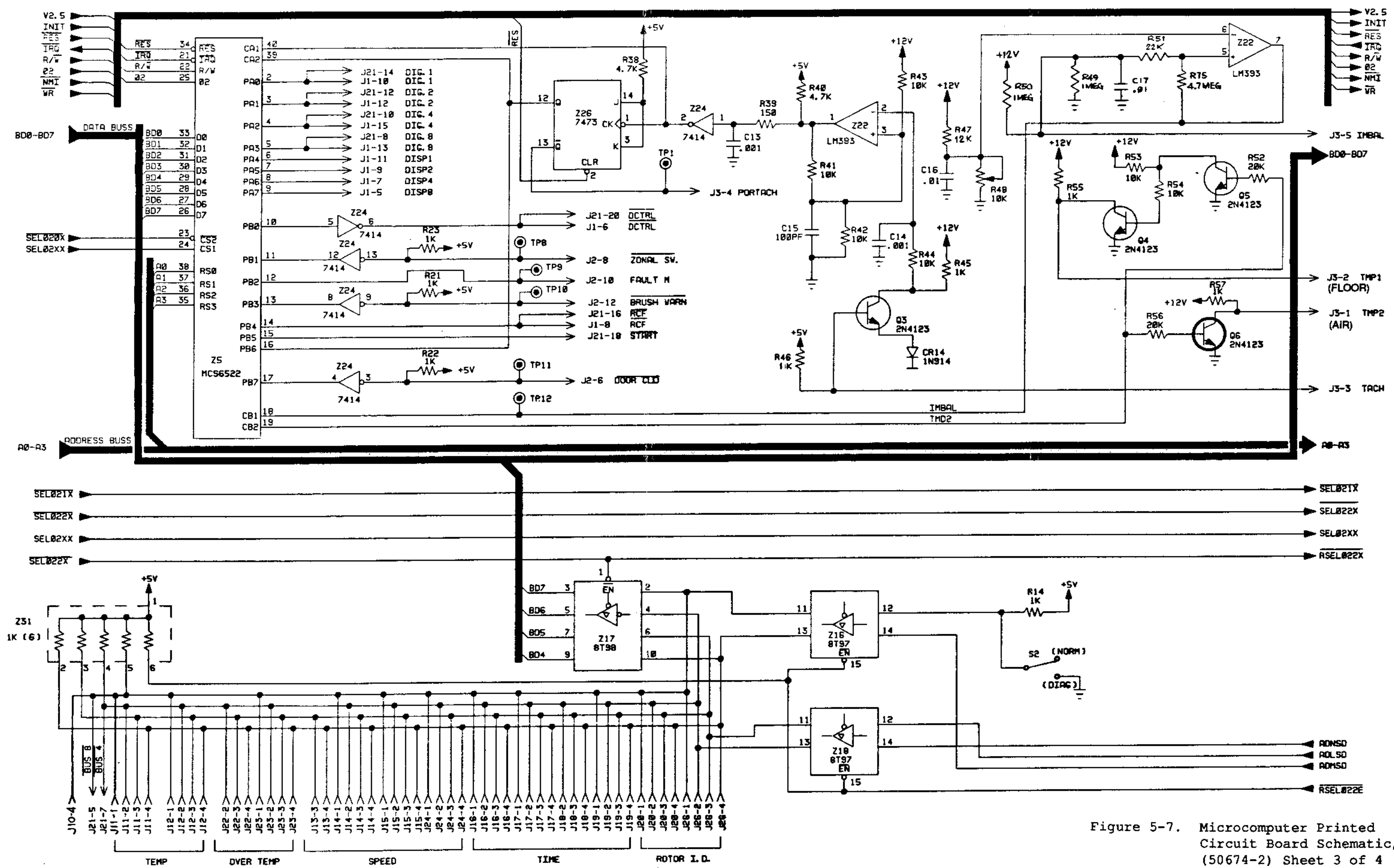


Figure 5-7. Microcomputer Printed Circuit Board Schematic, (50674-2) Sheet 3 of 4

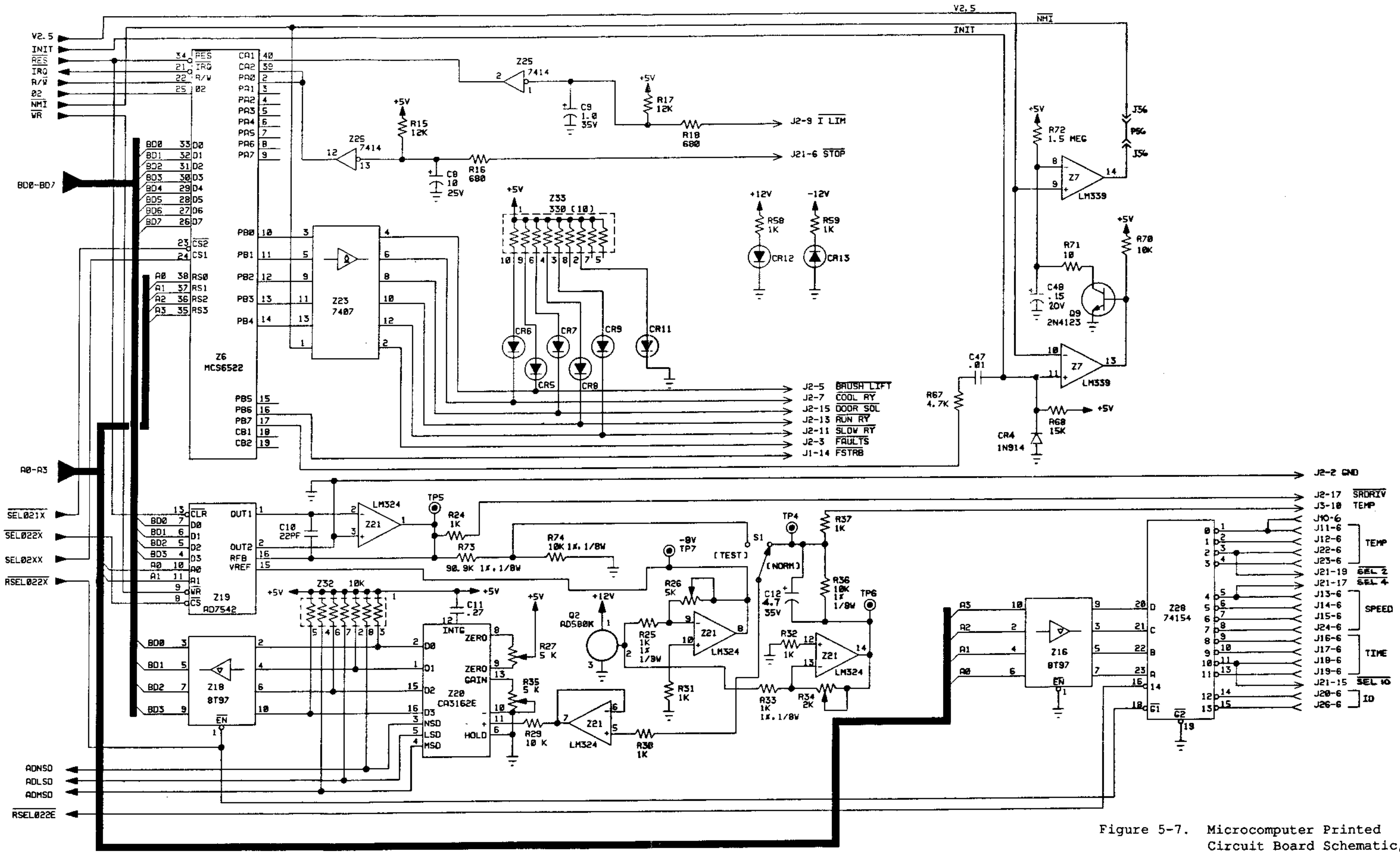


Figure 5-7. Microcomputer Printed Circuit Board Schematic, (50674-2) Sheet 4 of 4

NOTE

WHEN S2 IS OPEN = NORMAL MODE
WHEN S2 IS CLOSED = DIAGNOSTIC MODE

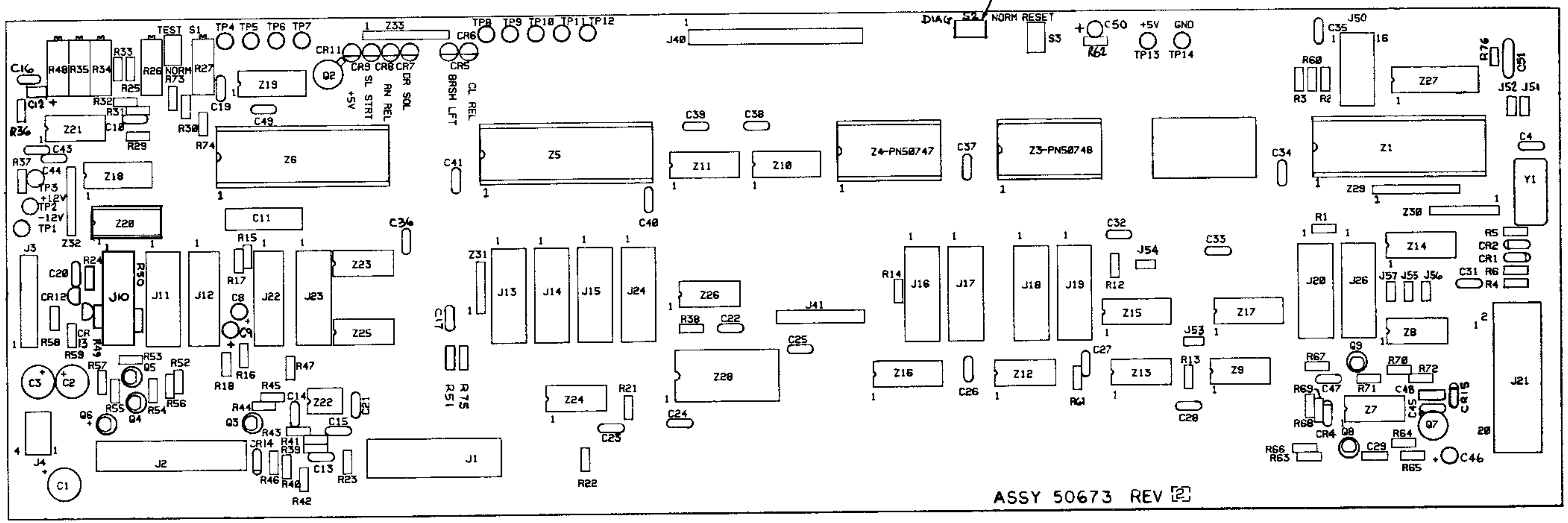


Figure 5-8. Microcomputer Printed Circuit Board Component Locations, (50673-2)

Table 5-2. Microcomputer Board Component Identification
(Refer to Figure 5-8)

Component	Description	Manufacturer Order Number
R1,R2,R3, R6,R60,R66	Resistor, Fixed, Carbon Compound, 3.3K Ohms, 1/4W,±5%	*
R4,R12,R13, R38,R40,R67	Resistor, Fixed, Carbon Compound, 4.7K Ohms, 1/4W,±5%	*
R5	Resistor, Fixed, Carbon Compound, 330K Ohms, 1/4W,±5%	*
R14,R21,R22, R23,R24,R30, R31,R32,R37, R45,R55,R57, R58,R59	Resistor, Fixed, Carbon Compound, 1K Ohms, 1/4W,±5%	*
R15,R17	Resistor, Fixed, Carbon Compound, 12K Ohms, 1/4W,±5%	*
R16,R18	Resistor, Fixed, Carbon Compound, 680 Ohms, 1/4W,±5%	*
R25,R33	Resistor, Metal Film, 1K Ohms, 1/8W, ±1%	#RN55D1001F
R26,R27,R35	Resistor, Variable, Cermet, P.C. Type, 5K Ohms	BOURNS #3009P-1-502
R29,R41,R42, R43,R44,R53, R54,R63,R69, R70	Resistor, Fixed, Carbon Compound, 10K Ohms, 1/4W, ±5%	*
R34	Resistor, Variable, Cermet, P.C. Type, 2K Ohms	BOURNS #3009P-1-202
R36,R74	Resistor, Metal Film, 10k Ohms, 1/8W, ±1%	ALLEN BRADLEY #CC1002E
R39	Resistor, Fixed, Carbon Compound, 150 Ohms, 1/4W,±5%	*
R46	Resistor, Fixed, Carbon Compound, 4K Ohms, 1/4W,±5%	*
R47	Resistor, Fixed, Carbon Compound, 47K Ohms, 1/4W,±5%	*

*Standard component available through most suppliers.

Table 5-2. Microcomputer Board Component Identification (Refer to Figure 5-8), continued

Component	Description	Manufacturer Order Number
R48	Resistor, Variable Cermet, P.C. Type, 10K Ohms	BOURNS #3009P-1-103
R49,R50	Resistor, Fixed, Carbon Compound, 1 MEG Ohms, 1/4W, ±5%	*
R51	Resistor, Fixed, Carbon Compound, 2 MEG Ohms, 1/4W, ±5%	*
R52,R56	Resistor, Fixed, Carbon Compound, 20K Ohms, 1/4W, ±5%	*
R61	Resistor, Metal Film, 5.62K Ohms, 1/8W, ±1%	DALE #CMF-55-T1-5.6K-1%
R62	Resistor, Metal Film, 9.09K Ohms, 1/8W, ±1%	DALE #CMF-55-T1-9.09K-1%
R64,R71	Resistor, Fixed, Carbon Compound, 10 Ohms, 1/4W, ±5%	*
R65	Resistor, Fixed, Carbon Compound, 510K Ohms, 1/4W, ±5%	*
R68	Resistor, Fixed, Carbon Compound, 15K Ohms, 1/4W, ±5%	*
R72	Resistor, Fixed, Carbon Compound, 1.5 MEG Ohms, 1/4W, ±5%	*
R73	Resistor, Metal Film, 90.9K Ohms, 1/8W, ±5%	DALE #CMF-55-T1-90.9K-1%
R75	Resistor, Fixed, Carbon Compound, 4.7 MEG Ohms, 1/4W, ±5%	*
TP1,TP2,TP3, TP4,TP5,TP6, TP7,TP8,TP9, TP10,TP11, TP12,TP13, TP14	Terminal, Swage, 2 Turrett, Brass, Silver Plated	H. H. SMITH P/N 2018C
Q3, Q4, Q5, Q6, Q8, Q9	Transistor, NPN	MOTOROLA #2N4123
Q7	Integrated Circuit, Voltage Ref., Low Drift, 2.5 Volts	ANALOG #AD580J

Table 5-2. Microcomputer Board Component Identification (Refer to Figure 5-8), continued

Component	Description	Manufacturer Order Number
CR1,CR2,CR4 CR14	Diode, Silicon, Switching	FAIRCHILD #IN914
CR5,CR6,CR7, CR8,CR9,CR10, CR11,CR12, CR13	Diode, Light Emitting, Red	GENERAL INSTRUM #MV5055
C1,C2,C3	Capacitor, Electrolytic, Aluminum, 47 MFD, 35 WVDC	SPRAGUE #503D476F035NB
C4	Capacitor, Ceramic Disc, 10PF, 1000 WVDC	SPRAGUE #561C0GBA102AE100D
C8	Capacitor, Electrolytic, Aluminum, 10 MFD, 25 WVDC	ILLINOIS #106R1R025M
C9	Capacitor, Fixed, Tantalum, 1.0 MFD, 35 WVDC	SPRAGUE #196D105X9035HAI
C10	Capacitor, Ceramic Molded, 22 PF, 200 WVDC	SPRAGUE #CKR05BX220K1
C11	Capacitor, Filmite "E", Pacer, .27 MFD, 80 WVDC	SPRAGUE #192P2749R8
C12,C46	Capacitor, Fixed Tantalum, .1 MFD, 35 WVDC	SPRAGUE #196D104X9035HAI
C13,C14	Capacitor, Ceramic Molded, 1000 PF, 200 WVDC	SPRAGUE #CKR05BX102KL
C15	Capacitor, Ceramic Molded, 100 PF, 200 WVDC	SPRAGUE #CKR05BX101KL
C16,C17,C19, C20,C21,C22, C23,C24,C25, C26,C27,C28, C29,C31,C32, C33,C34,C35, C36,C37,C38, C39,C40,C41, C42,C43,C44, C45,C47,C49	Capacitor, Ceramic Molded, .01 MFD, 100 WVDC	SPRAGUE #CKR05BX103ML

Table 5-2. Microcomputer Board Component Identification (Refer to Figure 5-8), continued

Component	Description	Manufacturer Order Number
C48	Capacitor, Fixed Tantalum, .15 MFD, 20 VDC	MALLORY #TDC154M020AS
Y1	Crystal 1 MHZ	CLARK CRYSTAL P/N CL-19
S1,S2	Switch, SPDT, Toggle, P.C. Type, Subminiature 0.4 VA Max	ALCO #TT11DG-PC-1
S3	Switch, SPST, Mini-Pushbutton, P.C. Type, 0.4 VA Max	ALCO #TP811CG-PC-2
Z1	Integrated Circuit, Microprocessor	MOS TECHNOLOGY, INC. #MCS 6502
Z2	Memory, Programmed, 2800-RC5C	*
Z3	Memory, Programmed, 3000-RC5C	*
Z4	Memory, Programmed, 3800-RC5C	*
Z5,Z6	Integrated Circuit, Versatile, Interface Adapter	MOS TECHNOLOGY, INC. #MCS 6522
Z7	Integrated Circuit, Analog, Quad Comparator	NATIONAL #LM339N
Z8,Z9	Integrated Circuit, Digital, Hex Inverter, TO-116	TEXAS INSTRUMENTS #SN7404N
Z10,Z11	Integrated Circuit, 1024-Bit Static MOS RAM (256X4)	SIGNETICS #2112-2
Z12	Integrated Circuit, Quad 2, Input Positive, NAND GATE, 14 Pin	TEXAS INSTRUMENTS #5N7400N
Z13	Integrated Circuit, Quad 2, Input Positive, NOR GATE, 14 Pin DIP	TEXAS INSTRUMENTS #SN74LS02N
Z14	Integrated Circuit, Decoder/Demultiplexer, 16 Pin DIP	TEXAS INSTRUMENTS #SN74LS138N
Z15	Integrated Circuit, Decoder/Demultiplexer, 16 Pin DIP	TEXAS INSTRUMENTS #SN74LS139N

Table 5-2. Microcomputer Board Component Identification (Refer to Figure 5-8), continued

Component	Description	Manufacturer Order Number
Z16,Z18	Integrated Circuit, High Speed, Hex Tri-State Buffer	SIGNETICS #8T97
Z17	Integrated Circuit, High Speed, Hex Tri-State Inverter	SIGNETICS #8T98
Z19	Integrated Circuit, 12-Bit, CMOS Multiplying DAC	ANALOG DEVICES #AD7542JN
Z20	Integrated Circuit, Analog/Digital Converter, Dual-In-Line	RCA #CA3162E
Z21	Integrated Circuit, Low Power Quad Amplifier	NAT'L. SEMICNDCTR. #LM324N
Z22	Integrated Circuit, Dual Differential Comparator	TEXAS INSTRUMENTS #LM393
Z23	Integrated Circuit, High Voltage Output, Hex BFR/DRVR W/Open Coll	TEXAS INSTRUMENTS #SN7407
Z24,Z25	Integrated Circuit, Hex Schmitt-Trigger Inverter	TEXAS INSTRUEMTS #SN7414N
Z26	Integrated Circuit, Dual J-K, Master Slave Flip-Flop, 14 Pin DIP	TEXAS INSTRUMENTS #SN7473N
Z27	Integrated Circuit, Octal Bustransceiver, 20 Pin DIP	TEXAS INSTRUEMTNS #SN74L5245
Z28	Integrated Circuit, 4 Line to 6 Line, Decoder/Demultiplexers	TEXAS INSTRUEMTNS #SN74154
Z29	Resistor, Network, 10 Pin, SIP, 10K, 1.25W	BOURNS #4310R-101-103J
Z30,Z32	Resistor, Network, 8 Pin, SIP, 10K, 1.0W	BOURNS #4308R-101-103J
Z31	Resistor, Network, 6 Pin, SIP, 1.0K, .75W	BOURNS #4306R-101-102J

Table 5-2. Microcomputer Board Component Identification (Refer to Figure 5-8), continued

Component	Description	Manufacturer Order Number
Z33	Resistor, Network, 10 Pin, SIP, 330 Ohms, 1.25W	BOURNS #4310R-101-331J
J1	Connector, P.C., RT. Angle, Low Profile, EJCTR, HDR, 16 Posn	T&B ANSLEY #609-1617ES
J2,J21	Connector, P.C., RT. Angle, Low Profile, EJCTR, HDR, 20 Posn	T&B ANSLEY #609-2017ES
J3	Connector, Polarizing & Locking Wafer, 10 Contacts	MOLEX #22-27-2101
J4	Connector, Plug, Elec, 6 Posn	MOLEX #10-18-1061
J11,J12,J13, J14,J15,J16, J17,J18,J19, J20,J22,J23, J24,J26	Connector, P.C., Card Edge, 6 Posn	EDAC #306-006-521-101
J40	Connector, P.C., Top Entry, 20 Posn	MOLEX #22-02-2201
J41	Connector, P.C., Top Entry, 10 Posn	MOLEX #22-02-2101
J51,J52,J53, J54,J55,J56, J57	Connector, Square Pin, Straight Wafer, 2 Contact	MOLEX #22-03-2021
P51,P52,P53, P54,P55,P56, P57	Plug, Interconnection, 2 Posn	BERG #65474-001
J50	Socket, I.C., Low Profile, 16 Pin	ARIES ELECTRONICS #16-512-10
P50	Shunt, Programmable, Dual-In-Line Package (DIP), STD. Pressure	AMP #435704-8

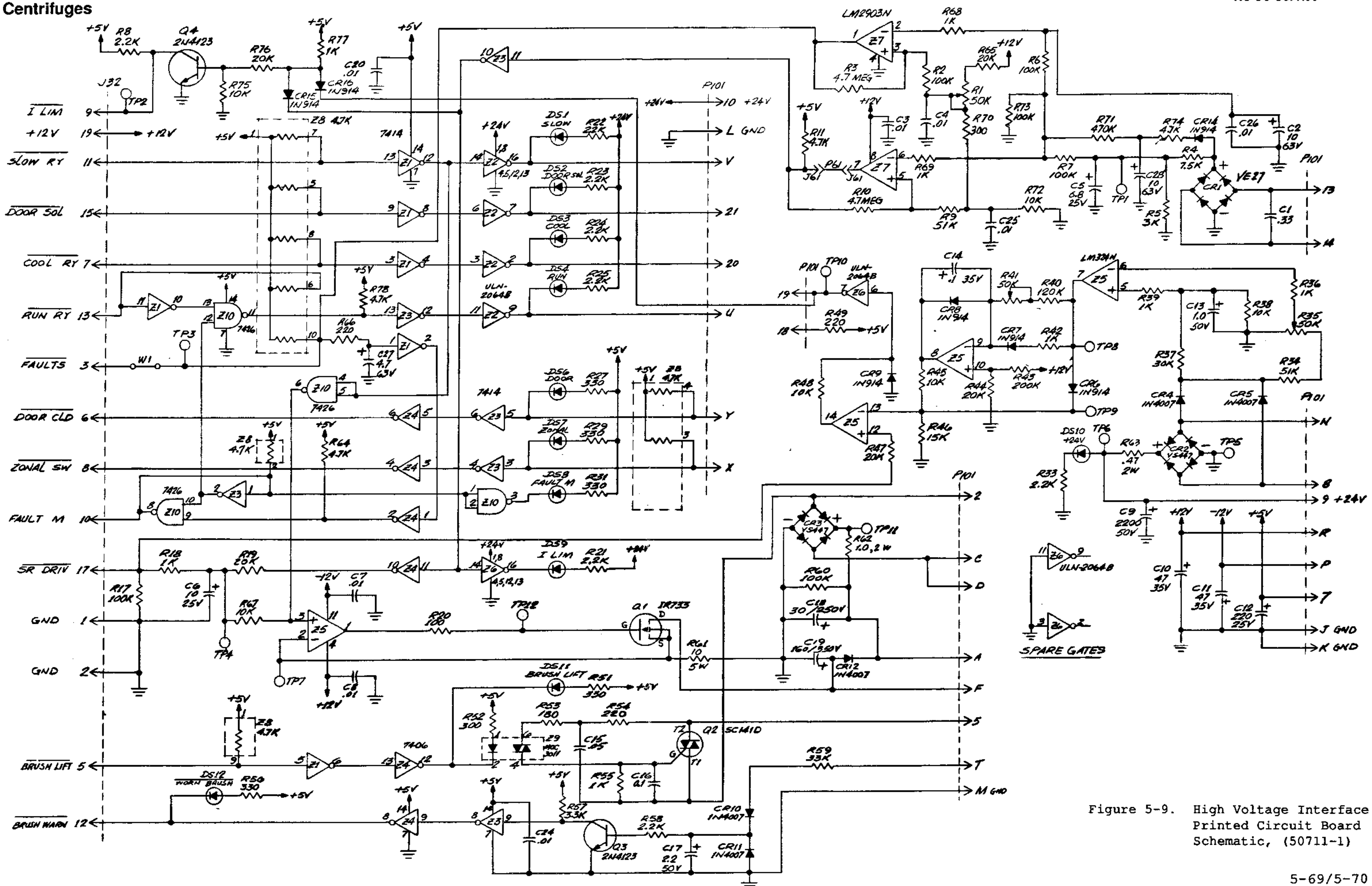


Figure 5-9. High Voltage Interface Printed Circuit Board Schematic, (50711-1)

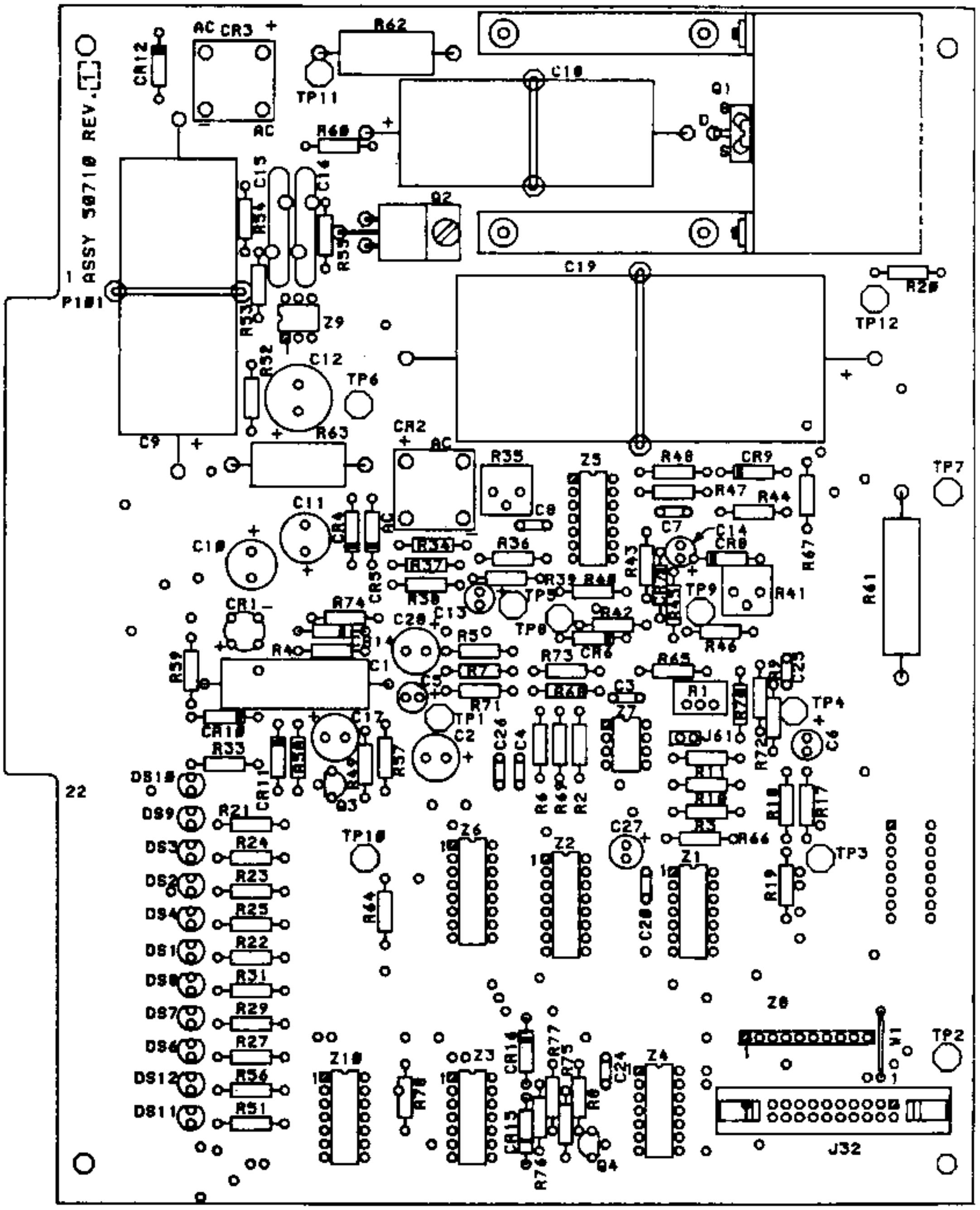


Figure 5-10. High Voltage Interface Printed Circuit Board Component Locations, (50710-1)

Table 5-3. High Voltage Interface Board Component Identification
(Refer to Figure 5-10)

Component	Description	Manufacturer Order Number
R1, R8	Resistor, Variable, P.C. Type 10K Ohms, 1/4W, ±5%	BOURNS #3386P-1-103
R2,R7,R9, R19,R38,R45, R48,R67	Resistor, Fixed, Carbon Composition, 10K Ohms, 1/4W, ±5%	*
R3	Resistor, Fixed, Carbon Composition, 1.5 MEG Ohms, 1/4W, ±5%	*
R4	Resistor, Fixed, Carbon Composition, 5100 Ohms, 1/4W, ±5%	*
R5	Resistor, Fixed, Carbon Composition, 820 Ohms, 1/4W, ± 5%	*
R6,R34	Resistor, Fixed, Carbon Composition, 51K Ohms, 1/4W, ±5%	*
R10,R43	Resistor, Fixed, Carbon Composition, 200K Ohms, 1/4W, ±5%	*
R11,R64	Resistor, Fixed, Carbon Composition, 4.7K Ohms, 1/4W, ±5%	*
R17,R60	Resistor, Fixed, Carbon Composition, 100K Ohms, 1/4W, ±5%	*
R18,R36,R39, R42,R55	Resistor, Fixed, Carbon Composition, 1K Ohms, 1/4W, ±5%	*
R20	Resistor, Fixed, Carbon Composition, 100 Ohms, 1/4W, ±5%	*
R21,R22,R23, R24,R25,R33, R58	Resistor, Fixed, Carbon Composition, 2.2K Ohms, 1/4W, ±5%	*
R27,R29,R31, R51,R56	Resistor, Fixed, Carbon Composition, 330 Ohms, 1/4W, ±5%	*
R35,R41	Resistor, Variable, P.C. Type, 50K Ohms	BOURNS #3386P-1-503
R37	Resistor, Fixed, Carbon Composition 30K Ohms, 1/4W, ±5%	*

Table 5-3. High Voltage Interface Board Component Identification (Refer to Figure 5-10), continued

Component	Description	Manufacturer Order Number
R40	Resistor, Fixed, Carbon Composition 27K Ohms, 1/4W, ±5%	*
R44,R47,R65	Resistor, Fixed, Carbon Composition, 20K Ohms, 1/4W, ±5%	*
R46	Resistor, Fixed, Carbon Composition, 15K Ohms, 1/4W, ±5%	*
R49,R54,R66	Resistor, Fixed, Carbon Composition, 220 Ohms, 1/4W, ±5%	*
R52	Resistor, Fixed, Carbon Composition, 300 Ohms, 1/4W, ±5%	*
R53	Resistor, Fixed, Carbon Composition, 180 Ohms, 1/4W, ±5%	*
R57	Resistor, Fixed, Carbon Composition, 3.3K Ohms, 1/4W, ±5%	*
R59	Resistor, Fixed, Carbon Composition, 33K Ohms, 1/4W, ±5%	*
R61	Resistor, Fixed, Wirewound, 5W, 10 ohms, ±5%	SPRAGUE #452E1005
R62	Resistor, Fixed, Carbon Composition, 1.0 Ohms, 1W, ±5%	*
R63	Resistor, Fixed, Carbon Composition, .47 Ohms, 2W, ±5%	*
CR1	Rectifier, Bridge, Epoxy, 200 V, 1 Amp	VARO #VE27
CR2,CR3	Rectifier, Bridge	VARO #VS447
CR4,CR5,CR10, CR11,CR12	Diode	MOTOROLA #IN4007
CR6,CR7,CR8, CR9	Diode, Silicon, Switching	FAIRCHILD #IN914
Q1	Transistor, Power, MOSFET	I.R. #IRF733

Table 5-3. High Voltage Interface Board Component Identification (Refer to Figure 5-10), continued

Component	Description	Manufacturer Order Number
Q2	Triac	G.E. #SC141D
Q3	Transistor, NPN	MOTOROLA #2N4123
C1	Capacitor, Filmite, .33 MFD, 50 WVDC	SPRAGUE #416P3349R5
C2	Capacitor, Electrolytic, Aluminum Radial, 100 MFD, 50 WVDC	SPRAGUE #503D107F050PD
C3,C4,C7,C8, C20,C24,C25, C26	Capacitor, Ceramic, Molded, .01 MFD, 100 WVDC	SPRAGUE #CKR05BX103ML
C5,C14	Capacitor, Fixed, Tantalum, .1 MFD, 35 WVDC	SPRAGUE #196D104X9035HA1
C6	Capacitor, Electrolytic, Aluminum Radial, 10 MFD, 25 WVDC	ILLINOIS #106RLR025M
C9	Capacitor, Electrolytic, Aluminum Radial, 2200 MFD, 50 WVDC	SPRAGUE #501D228F050TW
C10,C11	Capacitor, Electrolytic, Aluminum Radial, 47 MFD, 35 WVDC	SPRAGUE #503D476F035NB
C12	Capacitor, Electrolytic, Aluminum Radial, 220 MFD, 25 WVDC	SPRAGUE #503D227F025PD
C13	Capacitor, Electrolytic, Aluminum Radial, 1.0 MFD, 50 WVDC	ILLINOIS #105RLR050M
C15	Capacitor, Ceramic Disc, .05 MFD, +20%, 500 WVDC	SPRAGUE #C023A501P503M
C16	Capacitor, Ceramic Disc, .1 MFD, 500 WVDC	SPRAGUE #41C92A10
C17	Capacitor, Electrolytic, Aluminum Radial, 2.2 MFD, 50 WVDC	SPRAGUE #502D225F050BB1C
C18	Capacitor, Electrolytic, 16 MFD, 250 WVDC	MALLORY #TC54C

Table 5-3. High Voltage Interface Board Component Identification (Refer to Figure 5-10), continued

Component	Description	Manufacturer Order Number
C19	Capacitor, Electrolytic, Type TVA, 160 MFD, 350 WVDC	SPRAGUE #TVA1623
C27	Capacitor, Electrolytic, Aluminum Radial, 4.7 MFD, 63 WVDC	SPRAGUE #503D476F063LA
TP1,TP2,TP3, TP4,TP5,TP6, TP7,TP8,TP9, TP10,TP11, TP12	Terminal, Swage, 2 Turret, Brass, Silver Plated	H. H. SMITH #2018B
DS1,DS2,DS3, DS4,DS6,DS7, DS8,DS9,DS10, DS11,DS12	Lamp, Indicator, Red	GENERAL INSTRM. #MV5752
Z1,Z3	Integrated Circuit, Hex, Schmitt-Trigger Inverter	TEXAS INSTRUMENTS #SN7414N
Z2,Z6	Integrated Circuit, Darlington Switch	ULN #2064B
Z4	Integrated Circuit, Hex, Inverter, Buffer/Driver	TEXAS INSTRUMENTS #SN7406N
Z5	Integrated Circuit, Low Power Quad Amplifier	LM #324N
Z7	Integrated Circuit, Low Power, Low Offset Voltage, Dual Comparator	LM #2903N
Z8	Resistor Network, 4.7K, SIP, 10 Pin	BOURNS #4310R-101-472-J
Z9	Integrated Circuit, Triac Driver, Optically Isolated	MOC #3011
Z10	Integrated Circuit, Quad, 2 Input, High Voltage Interface, Pos. NAND Gate	TEXAS INSTRUMENTS #SN7426N

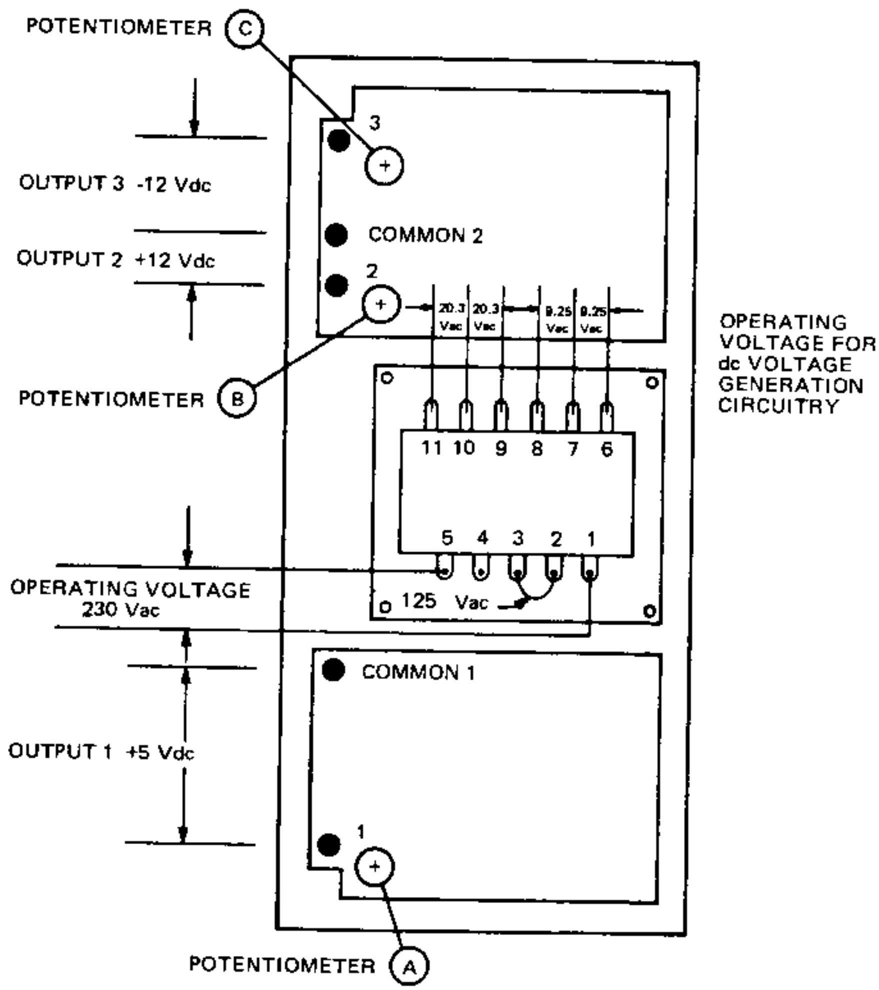
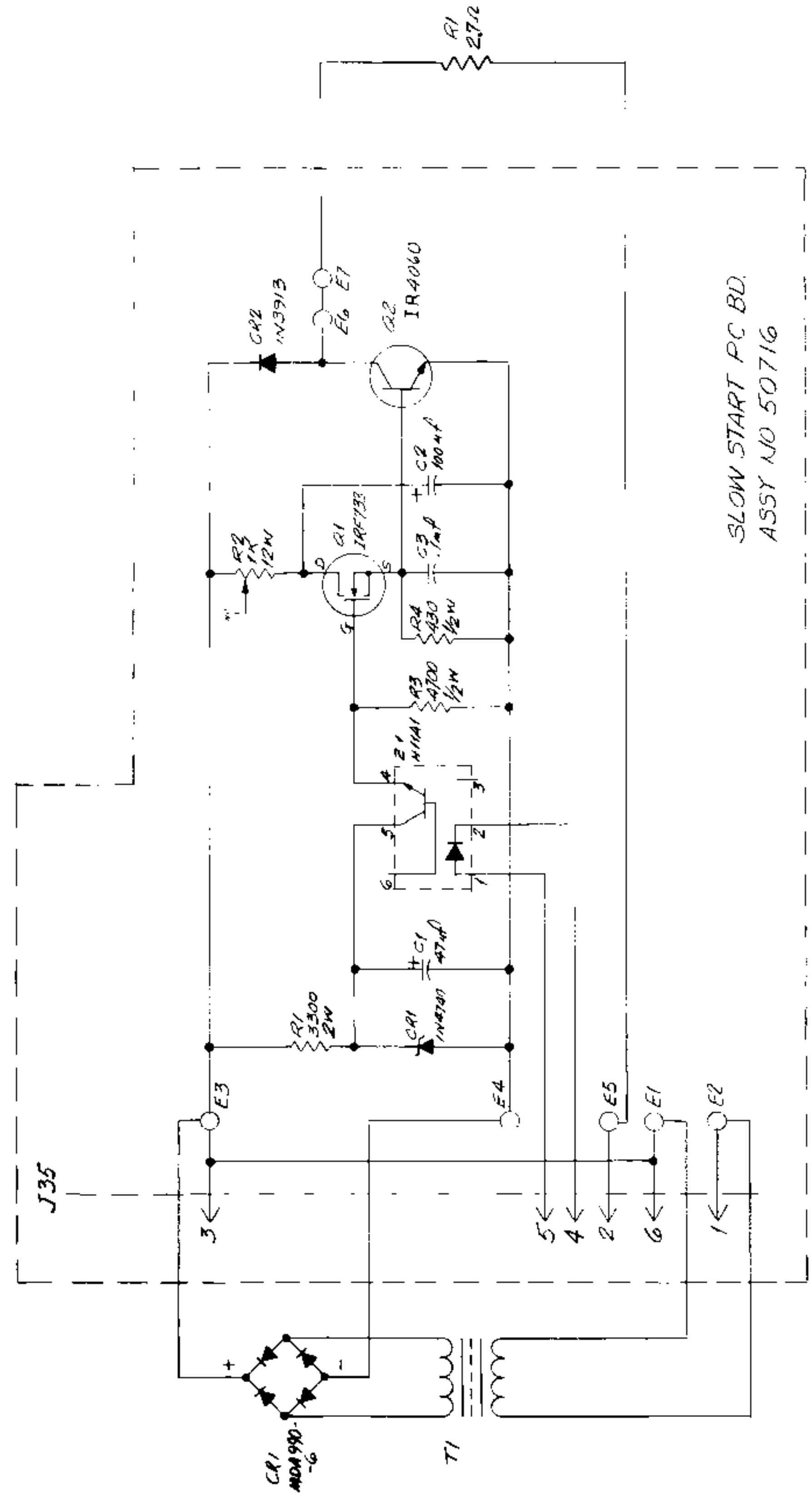


Figure 5-11. Power Supply Interface Schematic



J35

Pin	Description
1	230 Vac Input
2	Output to Saturable Reactor
3	230 Vac Return
4	0 - 50% Pulse Width Modulation Input from HVIF P.C. Board
5	0/+5 Vdc Brush Lift Signal from HVIF P.C. Board
6	230 Vac Return

Figure 5-12. Slow Start Printed Circuit Board Schematic, (50717-1)

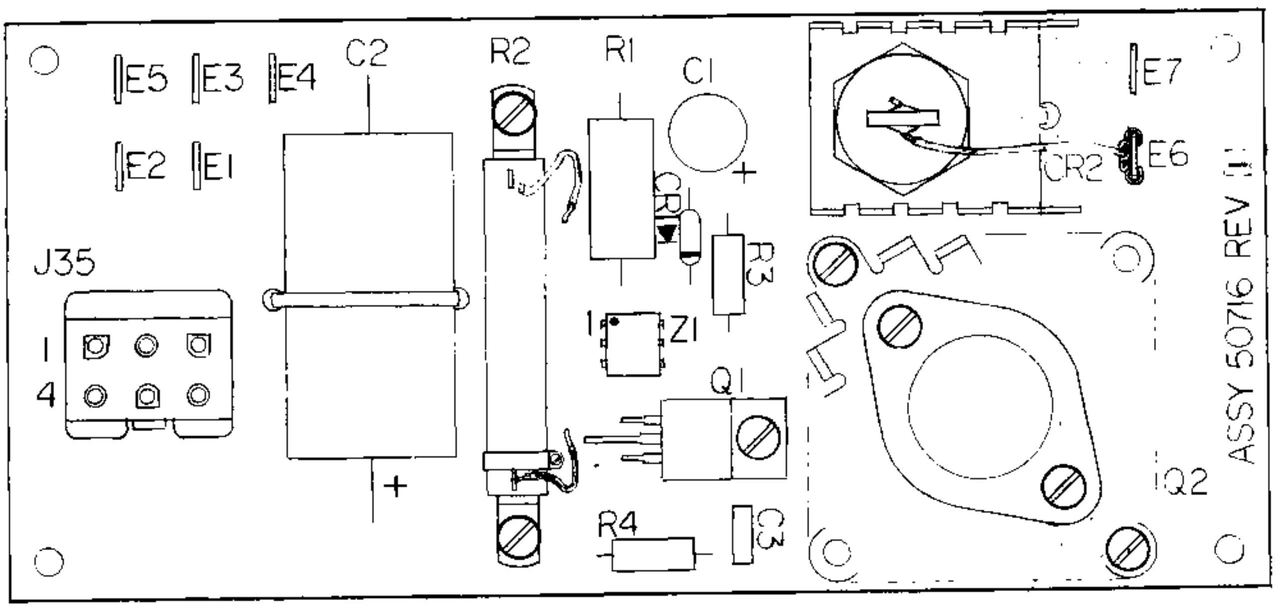
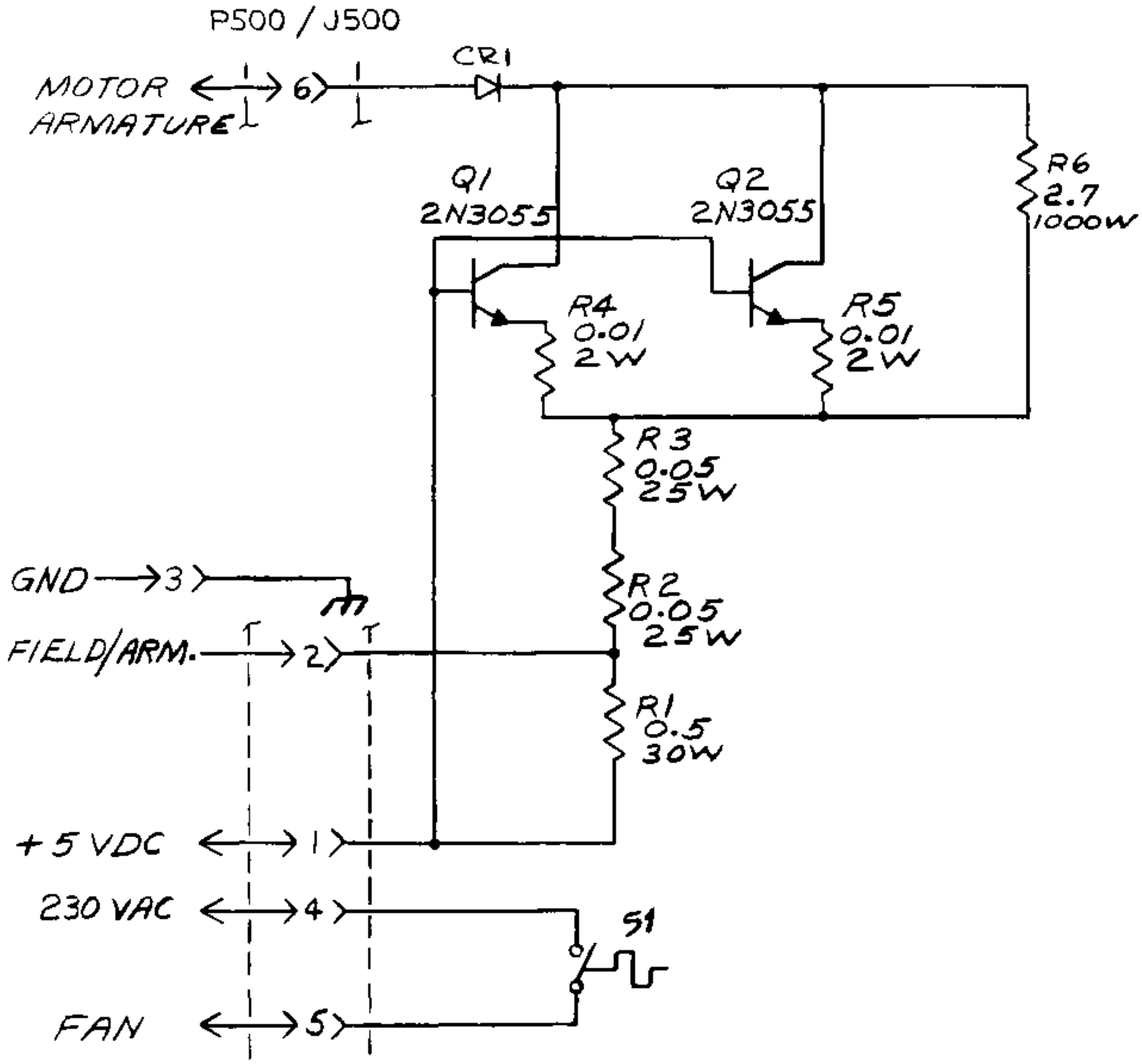


Figure 5-13. Slow Start Printed Circuit Board Component Locations, (50716-1)

Table 5-4. Slow Start Assembly Component Identification
(Refer to Figure 5-13)

Component	Description	Manufacturer Order Number
R1	Resistor, Fixed, Carbon Composition, 3300 Ohms, 2 W, ±5%	*
R2	Resistor, Variable, Enameled Vitreous, 1K Ohms, 12 W	OHMITE No. 1023
R3	Resistor, Fixed, Carbon Composition, 4700 Ohms, 1/2 W, ±5%	*
R4	Resistor, Fixed, Carbon Composition, 430 Ohms, 2 W, ±5%	*
C1	Capacitor, Electrolytic, 47 MFD, 35 WVDC	SPRAGUE No. 503D476F035NB
C2	Capacitor, Electrolytic, 100 MFD, 150 WVDC	SPRAGUE No. TVA1420
C3	Capacitor, Ceramic, .1 MFD, 100 WVDC	SPRAGUE No. CKR06BX104KL
CR1	Diode, Zener, Regulator, 25 ma, 1.0 W	MOTOROLA IN4740
CR2	Rectifier, Fast Recovery	G.E. #1N3913
Q1	Transistor, Power MOSFET	INT'L RECTIFIER #IRF733
Q2	Transistor, Power, NPN, TO3	INT'L RECTIFIER #IR4060
Z1	Integrated Circuit, Photon Coupled Isolator	MOTORLA #H11A1
E1,2,3,4, 5,6,7	Terminal, Male, Tab Fast-On, 250 P.C. Mount	*
J35	Connector Plug, Elect. 6-Position	MOLEX #19-09-2069



NOTE

Thermal Switch S1 is normally open, however, if brake cone resistor R6 generates excess heat S1 will close allowing the compressor fan to come on to cool the brake assembly.

Figure 5-14. Constant Current Brake Schematic, (50816-1)

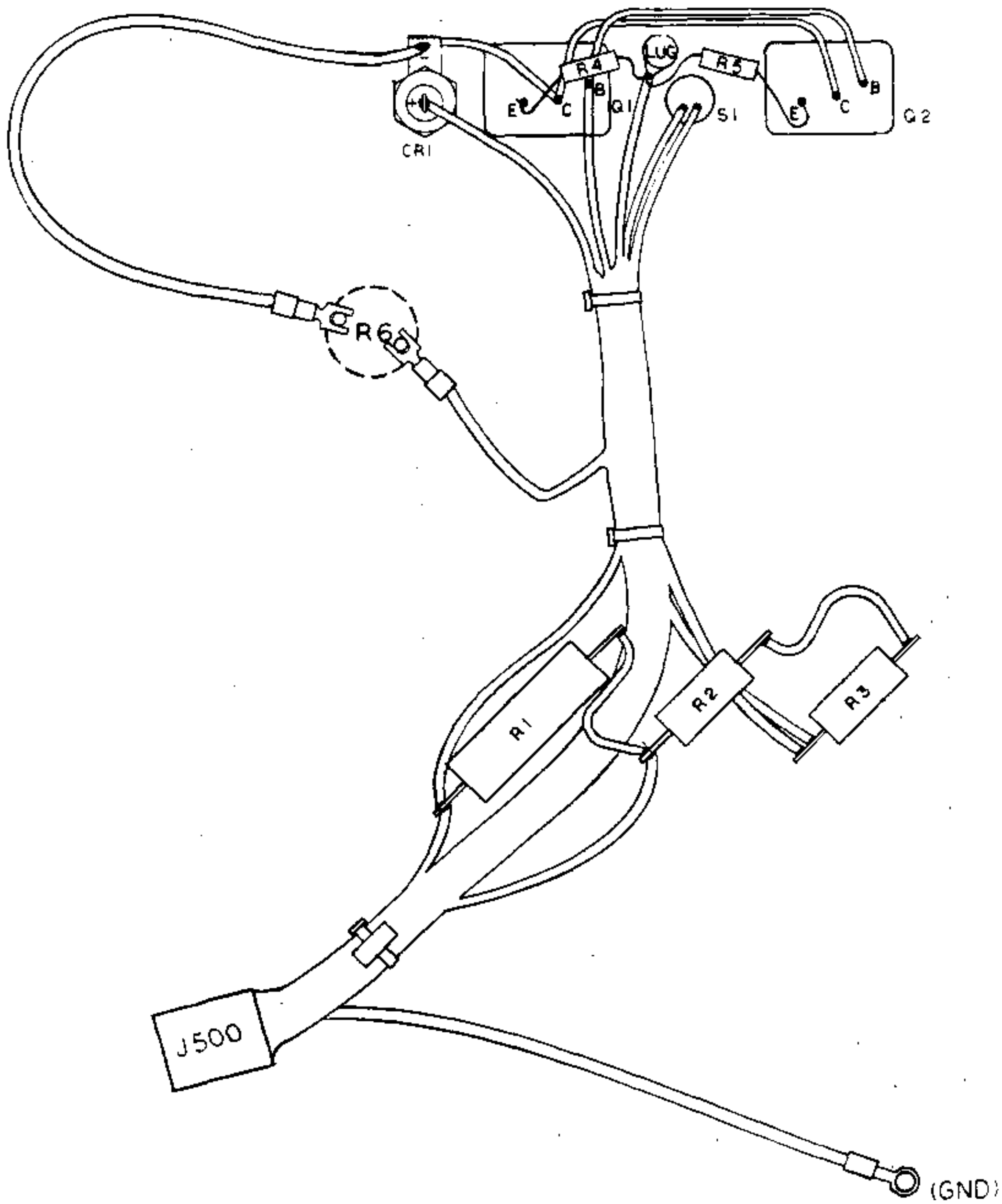


Figure 5-15. Constant Current Brake Harness Assembly
Component Locations, (50774-1)

Table 5-5. Constant Current Brake Assembly Component Identification (Refer to Figure 5-15)

Component	Description	Manufacturer/Order Number
S1	Thermostat, Non-Hermetic Open 112°F, Close 122°F	Elmwood #3001-24-106
R1	Resistor, Wirewound .5 Ohms, 30 W	Dale #ERH-50
R2,R3	Resistor, Wirewound .05 Ohms, 25 W	Dale #RH-25
R4,R5	Resistor, Wirewound .010 Ohms, 2 W	Dale #LVR-2
CR1	Rectifier, Silicon 100 V	G.E. #IN249C
Q1,Q2	Transistor, Power NPN	Motorola 2N3055
R6	Receptacle, Braking Resistor, 660 W, 250 V	*

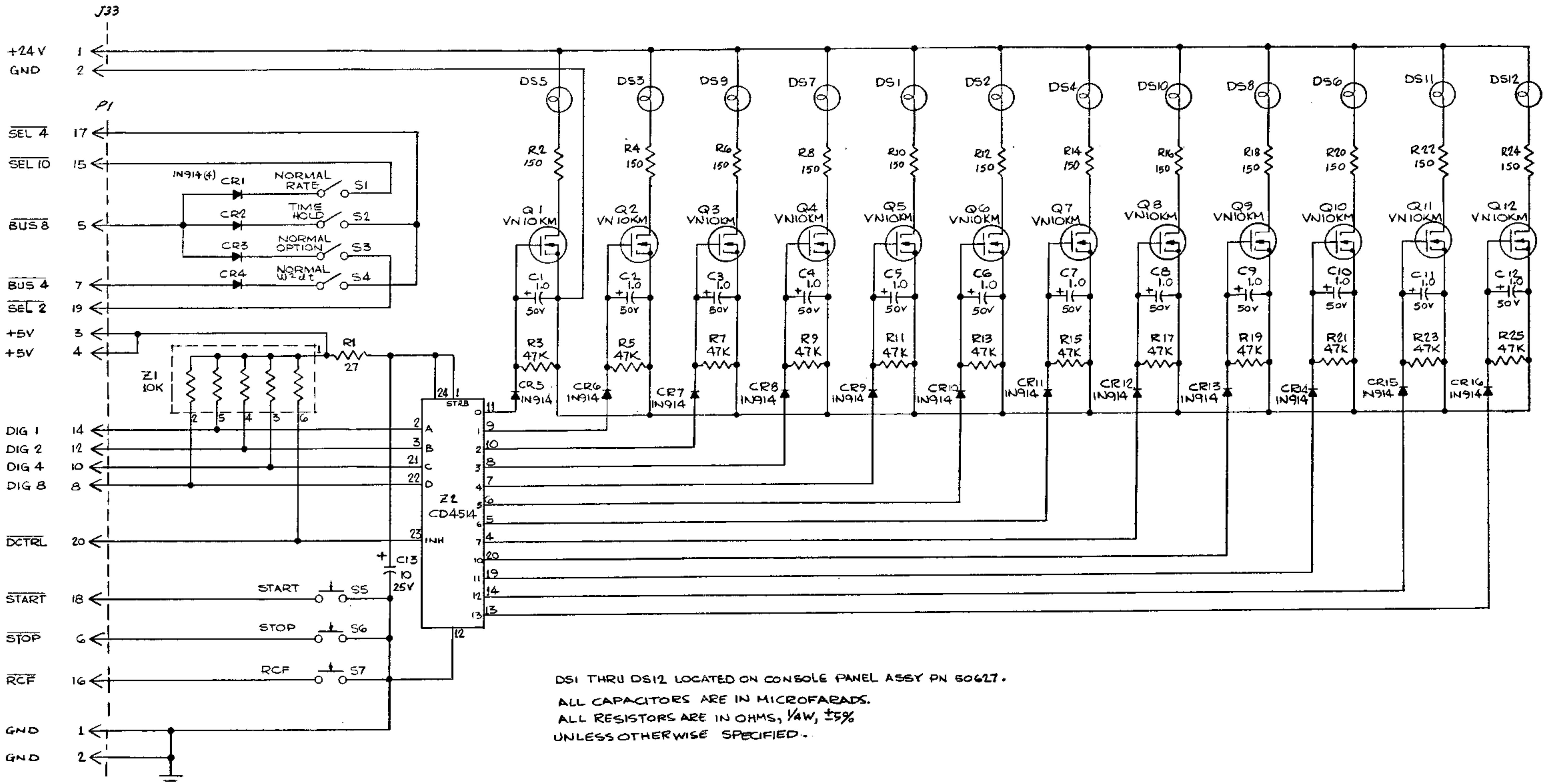


Figure 5-16. Switches and Indicators Printed Circuit Board Schematic, (50686-0)

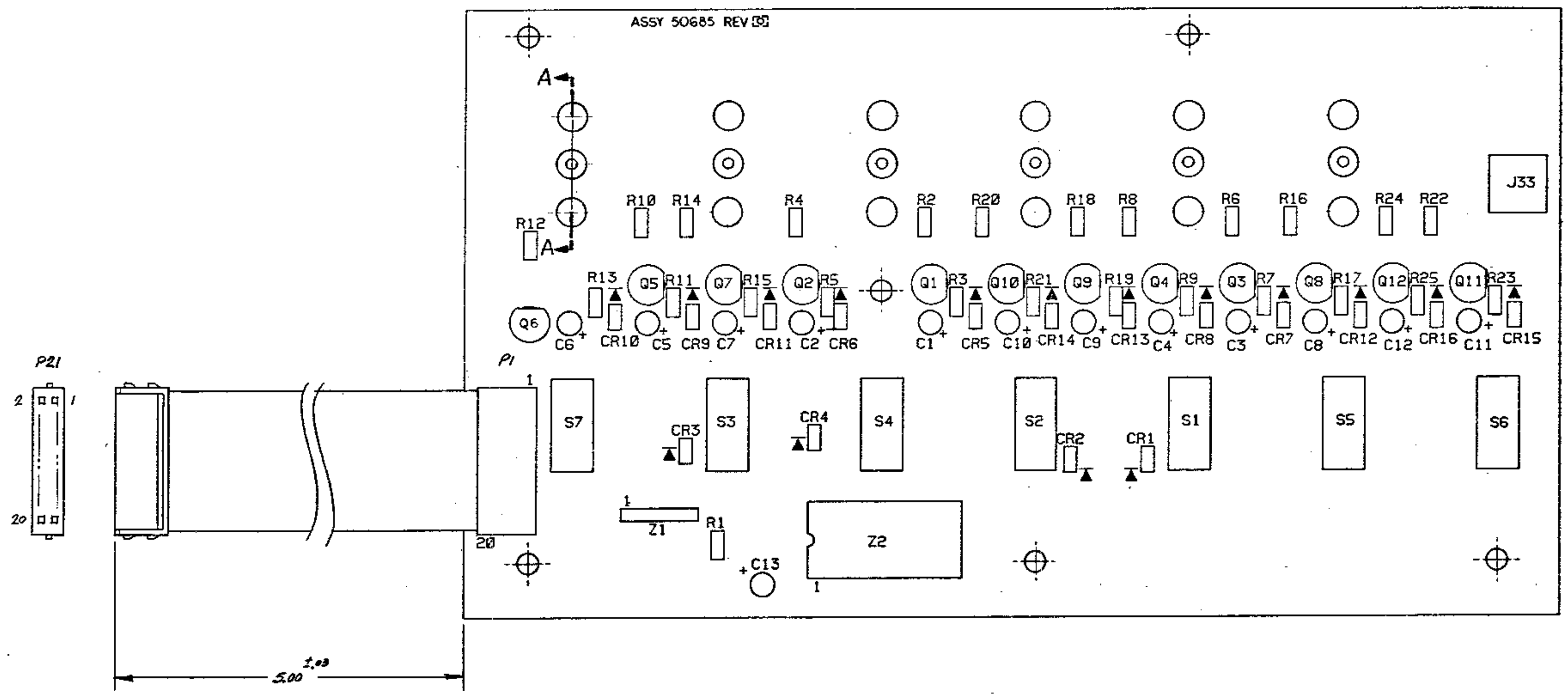


Figure 5-17. Switches and Indicators Printed Circuit Board Component Locations, (50685-0)

Table 5-6. Switches and Indicators Board Component Identification (Refer to Figure 5-17)

Component	Description	Manufacturer Order Number
P1	Connector, P.C. Solder Termination, 20 Position	ANSLEY #609-2003
P21	Connector, Ribbon, Female, Polarized, 20 Position	ANSLEY #609-2030
J33	Connector, Right-Angle, .156 Ctrs, 3 Position	MOLEX #09-75-1031
R2,R4,R6,R8, R10,R12,R14, R16,R18,R20, R22,R24	Resistor, Fixed Carbon Composition, 150 Ohms, 1/4 W, ±5%	*
R1	Resistor, Fixed Carbon Composition, 27 Ohms, 1/4 W, ±5%	*
R3,R5,R7,R9, R11,R13,R15, R17,R19,R21, R23, R25	Resistor, Fixed Carbon Composition, 47 Ohms, 1/4 W, ±5%	*
CR1,CR2,CR3, CR4,CR5,CR6, CR7,CR8,CR9, CR10,CR11, CR12,CR13, CR14,CR15, CR16	Diode, Signal Silicon	FAIRCHILD IN 914
C1,C2,C3,C4, C5,C6,C7,C8, C9,C10,C11, C12	Capacitor, Electrolytic 1.0 MF, 50 WVPC	ILLINOIS LAP #105RLR050M
Q1,Q2,Q3,Q4, Q5,Q6,Q7,Q8, Q9,Q10,Q11, Q12	Transistor, Power Fet, VMOS, N-channel enhancement mode	SILICONIX #VNIOKM
DS1,DS2,DS3, DS4,DS5,DS6, DS7,DS8,DS9, DS10,DS11, DS12	Lamp, Incandescant	CM#385

Table 5-6. Switches and Indicators Board Component Identification (Refer to Figure 5-17), continued

Component	Description	Manufacturer Order Number
S1,S2,S3,S4	Switch, P.C. Mounted, Toggle SPDT, PN 67183	C&K #U11-J2-V3-Q-E With Blk. Paddle
Z1	Resistor, SIP, 10K, 6Pin	BOURNS #4306-101-103J
Z2	Integrated Circuit, 4 Bit Latch/4 to 16 line, Decoder	RCA #CD4514BE
C13	Capacitor, Electrolytic, 10MF 25WVDC	ILLINOIS LAP #105RLR050M
S5	Switch, P.C. Mounted, Toggle, SPDT, PN 68048	C&K #U18-J2-V3-Q-E With Wht. Paddle
S6	Switch, P.C. Mounted, Toggle, SPDT, PN 68047	C&K #U18-J2-V3-Q-E With Red Paddle
S7	Switch, P.C. Mounted, Toggle, SPDT, PN 68049	C&K #U18-J2-V3-Q-E With Blk. Paddle

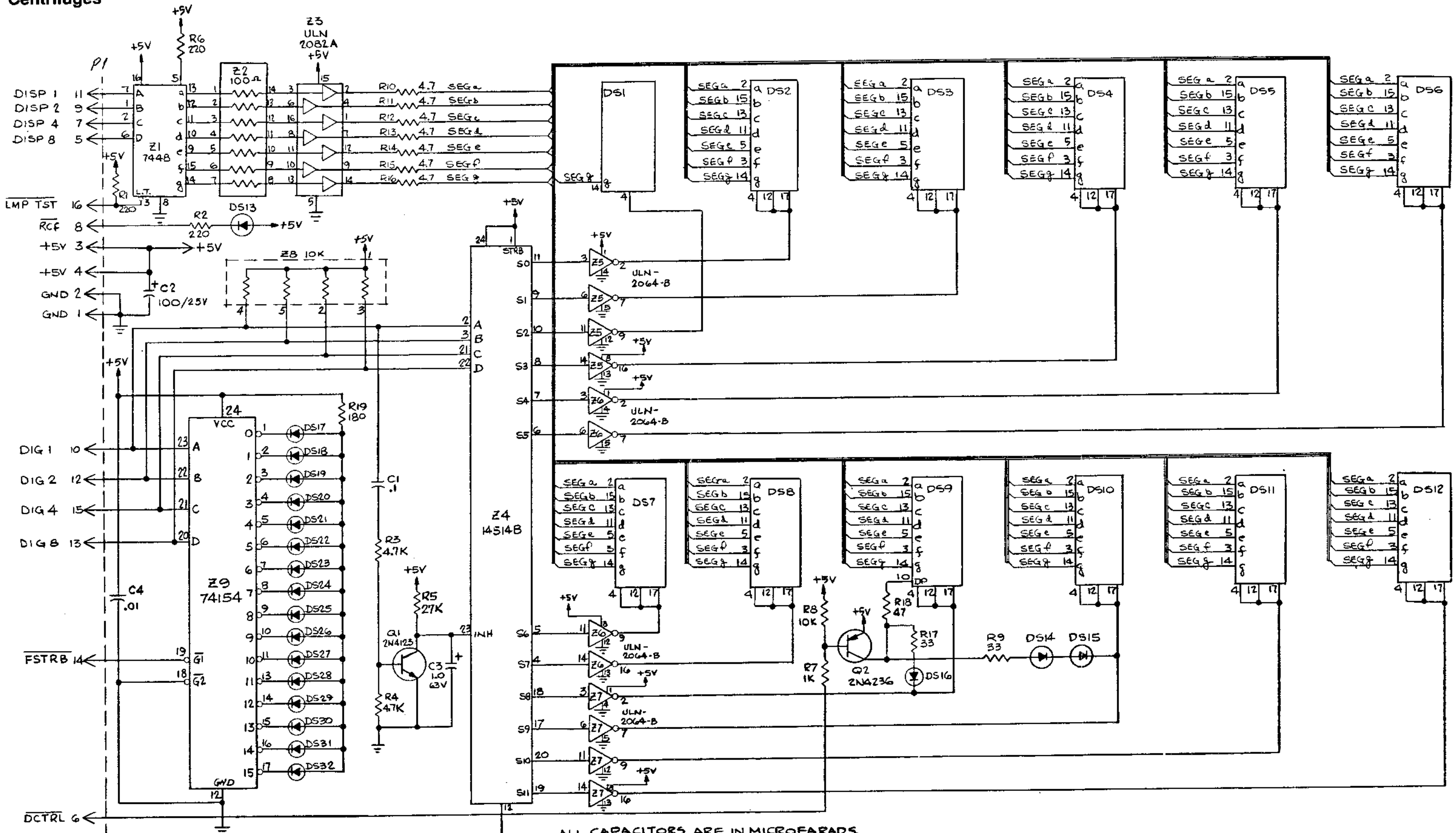


Figure 5-18. LED Display Printed Circuit Board Schematic, (50680-0)

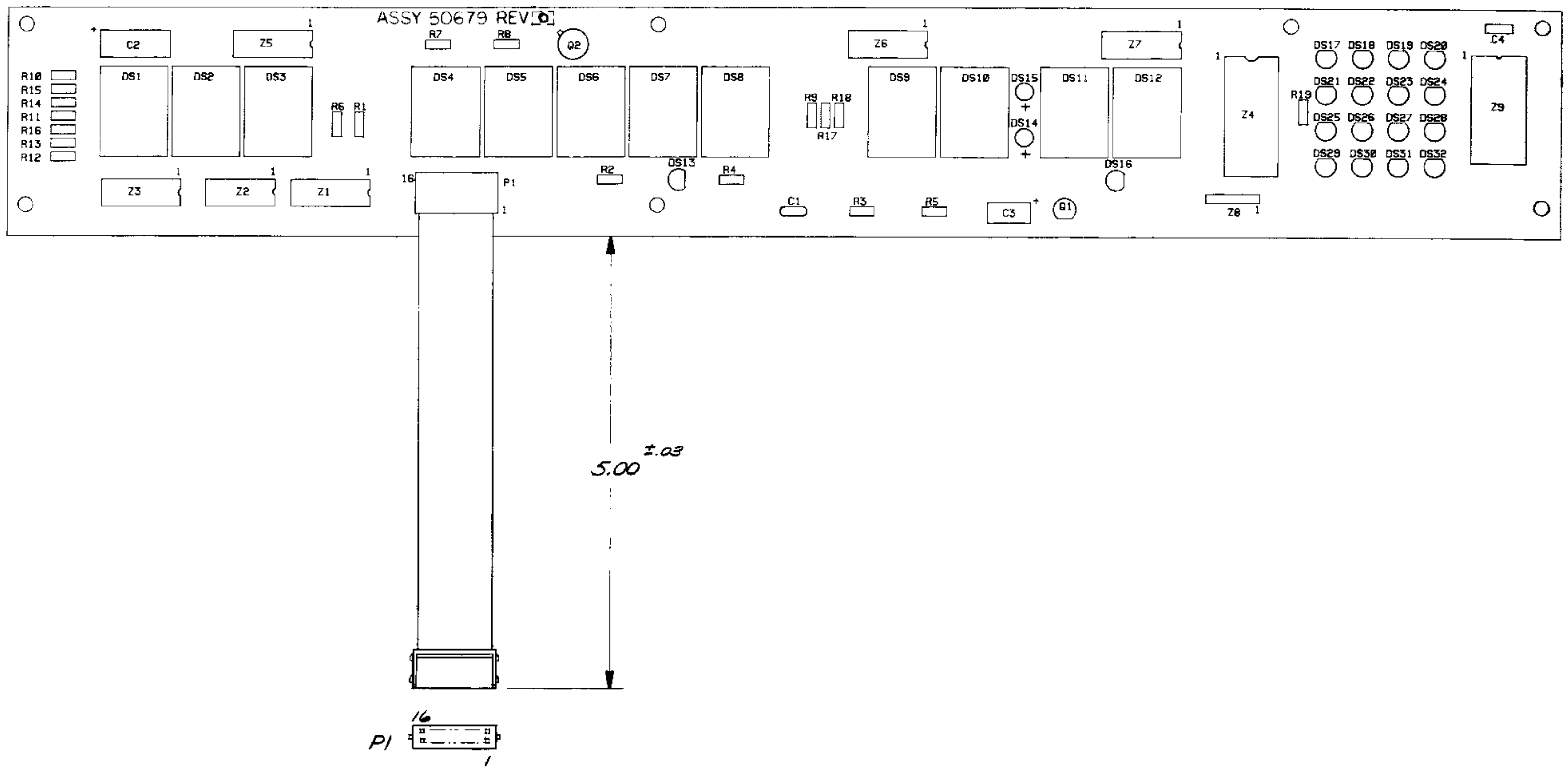


Figure 5-19. LED Display Printed Circuit Board Component Locations, (50679-0)

Table 5-7. LED Display Board Component Identification
(Refer to Figure 5-19)

Component	Description	Manufacturer Order Number
R1,R2,R6	Resistor, Fixed Carbon Composition, 220 Ohms, 1/4 W, ±5%	*
R3,R4	Resistor, Fixed Carbon Composition, 4.7 K Ohms, 1/4 W, ±5%	*
R5	Resistor, Fixed Carbon Composition, 27 K Ohms, 1/4 W, ±5%	*
R7	Resistor, Fixed Carbon Composition, 1 K Ohms, 1/4 W, ±5%	*
R8	Resistor, Fixed Carbon Composition, 10 K Ohms, 1/4 W, ±5%	*
R9,R17	Resistor, Fixed Carbon Composition, 33 Ohms, 1/4 W, ±5%	*
R10,R11,R12, R13,R14,R15, R16	Resistor, Fixed Carbon Composition, 4.7 Ohms, 1/4 W, ±5%	*
R18	Resistor, Fixed Carbon Composition, 47 K Ohms, 1/4 W, ±5%	*
R19	Resistor, Fixed Carbon Composition, 180 Ohms, 1/4 W, ±5%	*
C1	Capacitor, Ceramic, Molded, .1 MFD, 100 WVDC	SPRAGUE #CK R06BX104KL
C2	Capacitor, Electrolytic, Aluminum, 100 MFD, 25 WVDC	SPRAGUE #501 D107 E025MN
C3	Capacitor, Electrolytic, Aluminum, 1.0 MFD, 63 WVDC	SPRAGUE #501 D105 E063LL
C4	Capacitor, Ceramic, Molded, .01 MFD, 100 WVDC	SPRAGUE #CK R05BX103ML
Q1	Transistor, NPN	MOTOROLA #2N4123
Q2	Transistor, Power, Silicon, PNP	MOTOROLA #2N4236

Table 5-7. LED Display Board Component Identification
(Refer to Figure 5-19), continued

Component	Description	Manufacturer Order Number
DS1,DS2,DS3, DS4,DS5,DS6, DS7,DS8,DS9, DS10,DS11,DS12	DIODE, Light Emitting, Common Cathode, .800 IN, RHDP	MONSANTO #MAN 8640
DS13,DS16	Lamp, Indicator Green	GENERAL INSTRUMENT #MV5252
DS14,DS15	Lamp, Indicator Red	DIALIGHT #558-0101-001
DS17,DS18, DS19,DS20, DS21,DS22, DS23,DS24, DS25,DS26, DS27,DS28, DS29,DS30, DS31,DS32	Lamp, Indicator Yellow	GENERAL INSTRUMENT #MV5352
Z1	Integrated Circuit, BCD-to-Seven-Segment Decoders/Drivers	TEXAS INSTRUMENTS SN 7448
Z2	Resistor Network, 14 Pin DIP, 100 Ohms, 1.5 W	ALLEN-BRADLEY #314B101
Z3	Integrated Circuit, General Purpose High Current Transistor Array	SPRAGUE #ULN-2082A
Z4	Integrated Circuit, 4 Line to 6 Line Decoder, 24 Pin DIP	MOTOROLA #MC14514B PC
Z5,Z6,Z7	Integratea Circuit, Darington Switch, 16 Pin DIP	SPRAGUE #ULN-2064B
Z8	Resistor Network 6 Pin SIP 10K, .75W	BOURNS #4306R-101-103J
Z9	Integrated Circuit 4 Line to 16 Line, Decoder/Demultiplexer, 24 Pin	TEXAS INSTRUMENTS #SN 74154

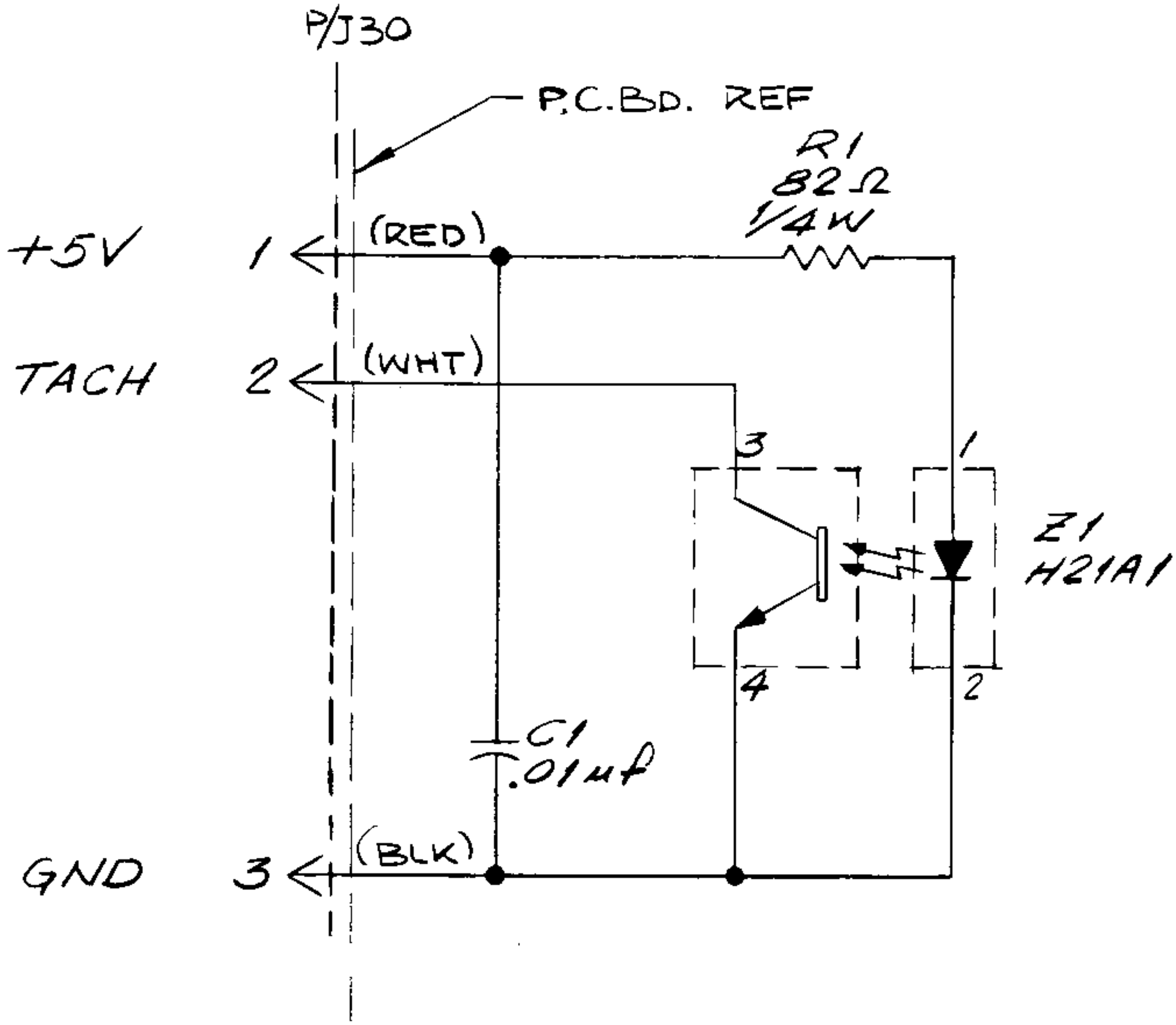
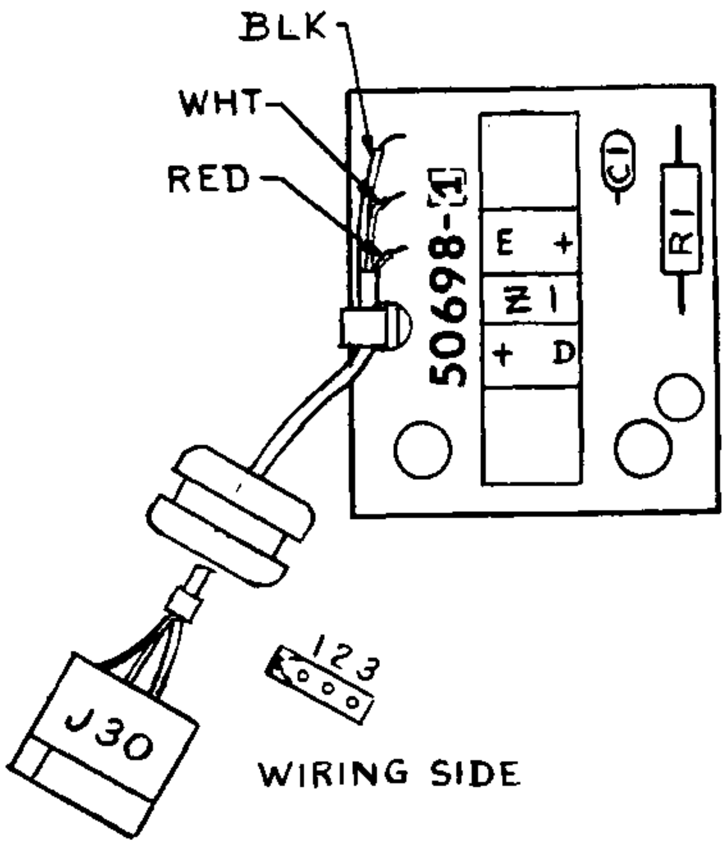


Figure 5-20. Tachometer Printed Circuit Schematic, (50699-1)



CABLE	FROM	TO	FUNCTION
RED	J30-1	RED	+5V
WHITE	J30-2	WHITE	TACH
BLACK	J30-3	BLACK	GND

Figure 5-21. Tachometer Printed Circuit Board Component Locations, (50698-1)

Table 5-8. Tachometer Board Component Identification
(Refer to Figure 5-21)

Component	Description	Manufacturer Order Number
Z1	Integrated Circuit, Photon Coupled, Interrupter Module	GE #H21A1
C1	Capacitor, ceramic molded .01 uF, 100W Vdc	SPRAGUE CKR05BX103ML
R1	Resistor, carbon, 82 ohms, 1/4W, ±5%	*
J30	Connector, body, plug, elec, 3 position	Molex #03-06-2032

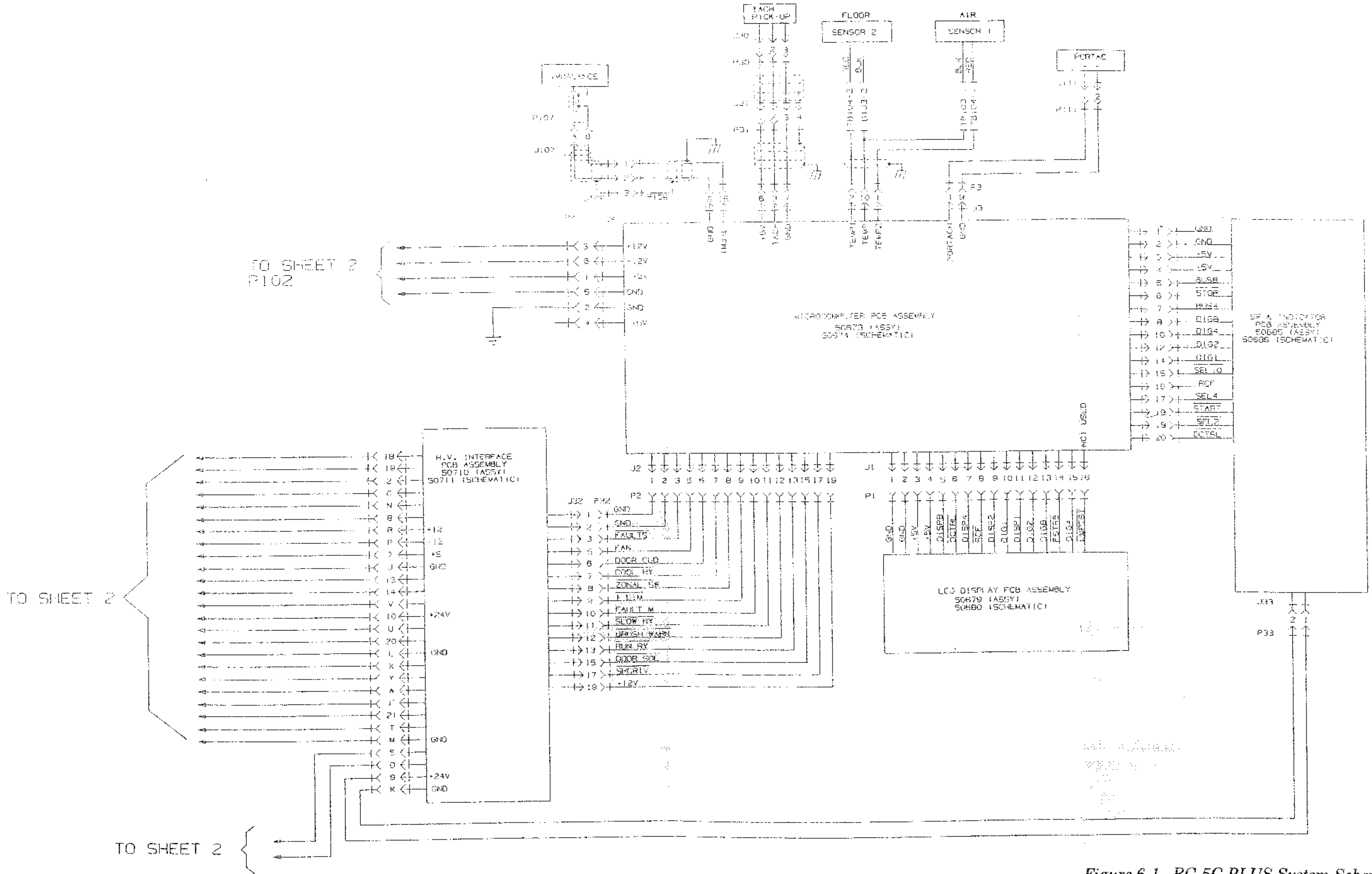


Figure 6-1. RC-5C PLUS System Schematic (Sheet 1 of 3)

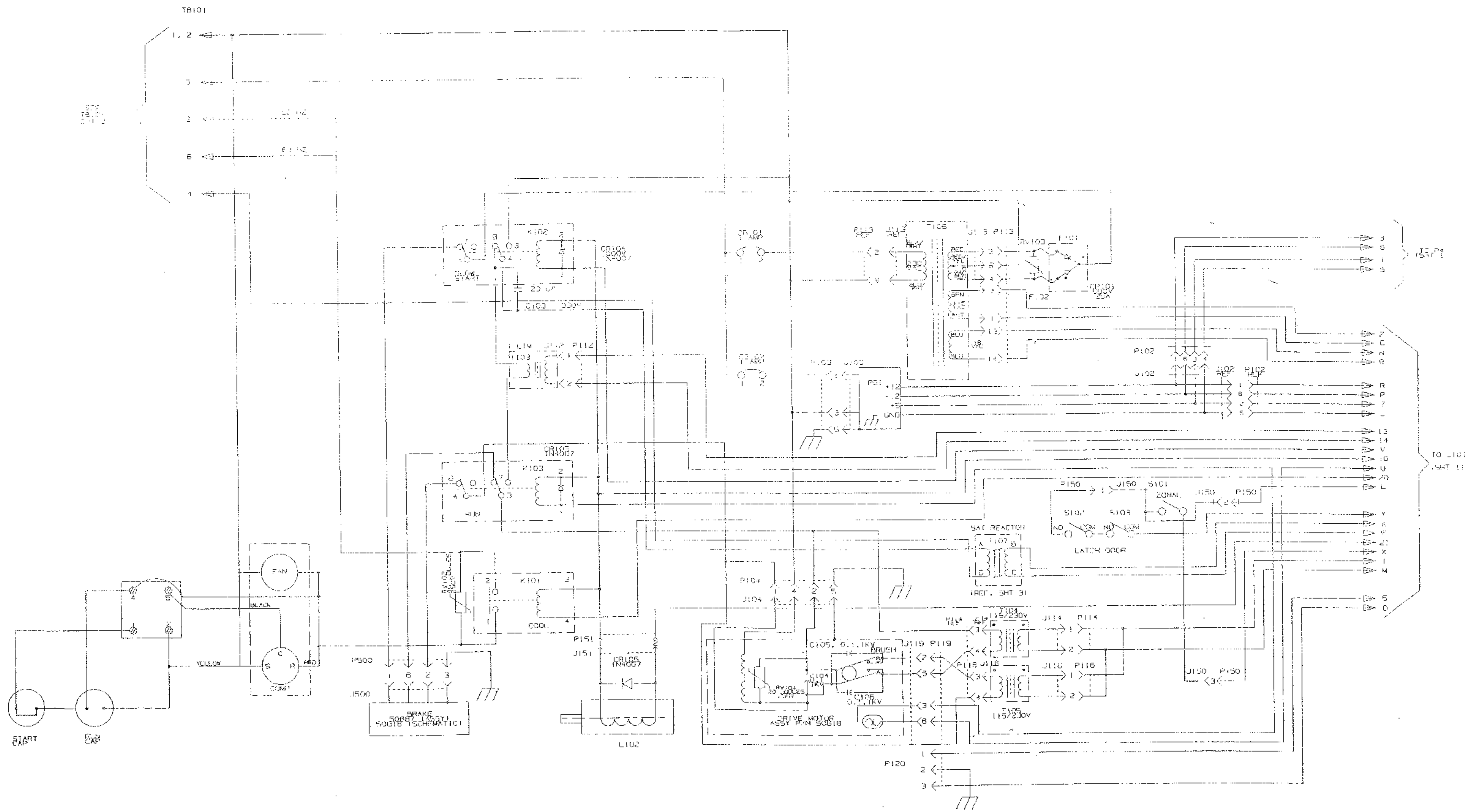
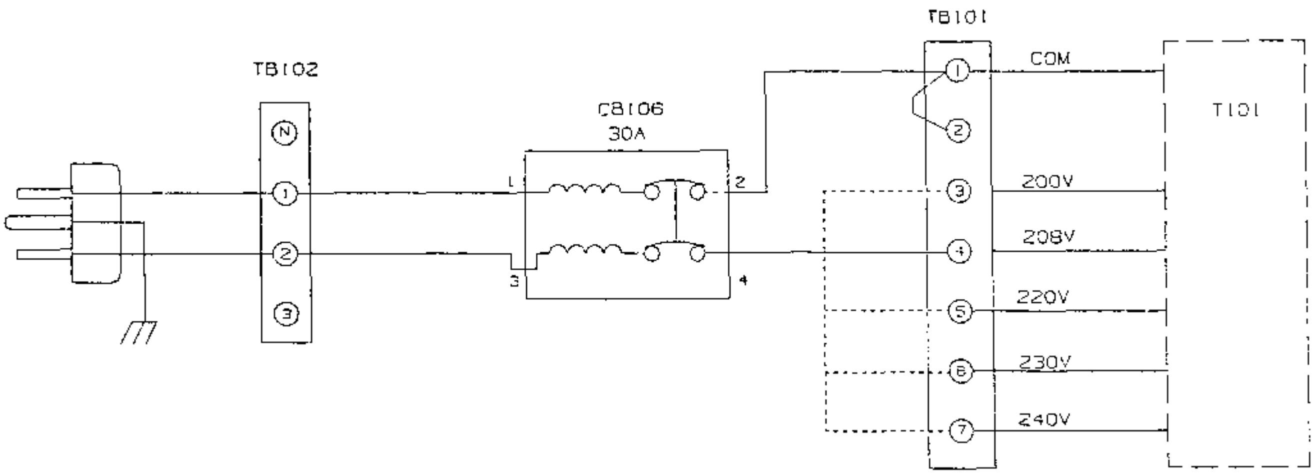


Figure 6-1. RC-5C PLUS System Schematic (Sheet 2 of 3)



200/240V, 50/60 HZ

NOTE The schematic above illustrates the circuit connection as 208 V. To change the input voltage, move the wire located at CB106-4 to the desired corresponding terminal on TB101.

Figure 6-1. RC-5C PLUS System Schematic (Sheet 3 of 3)

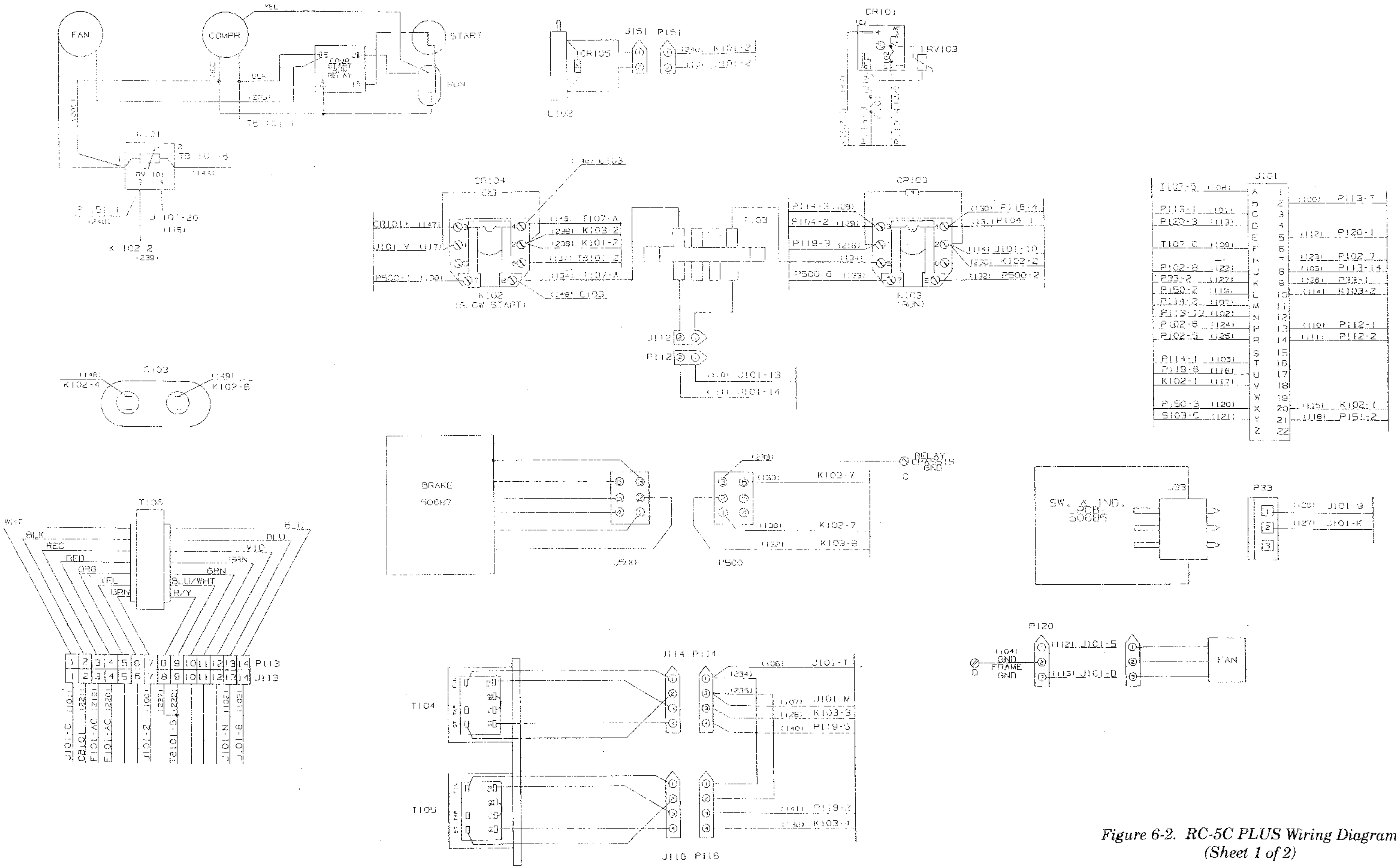


Figure 6-2. RC-5C PLUS Wiring Diagram (Sheet 1 of 2)

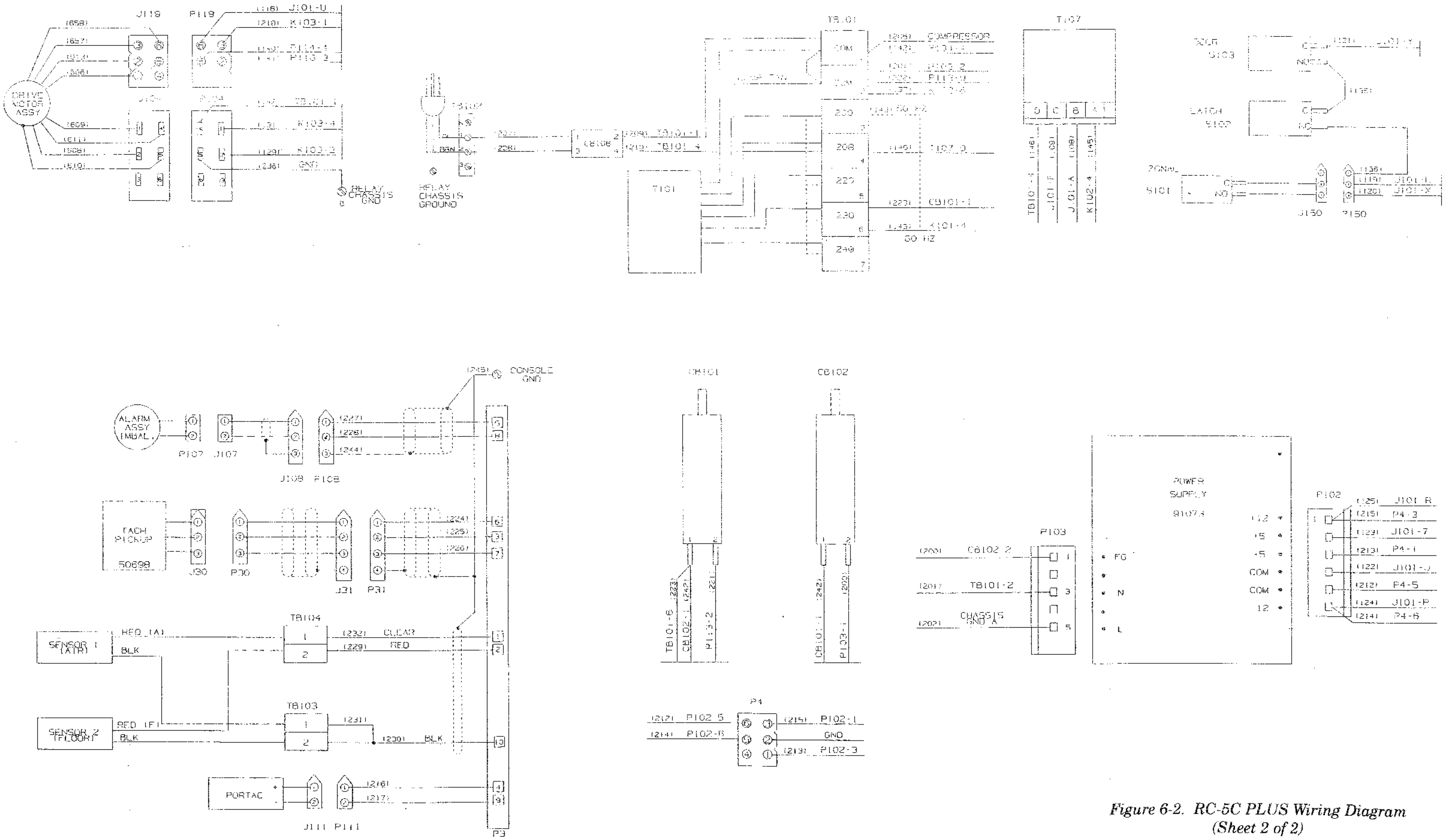
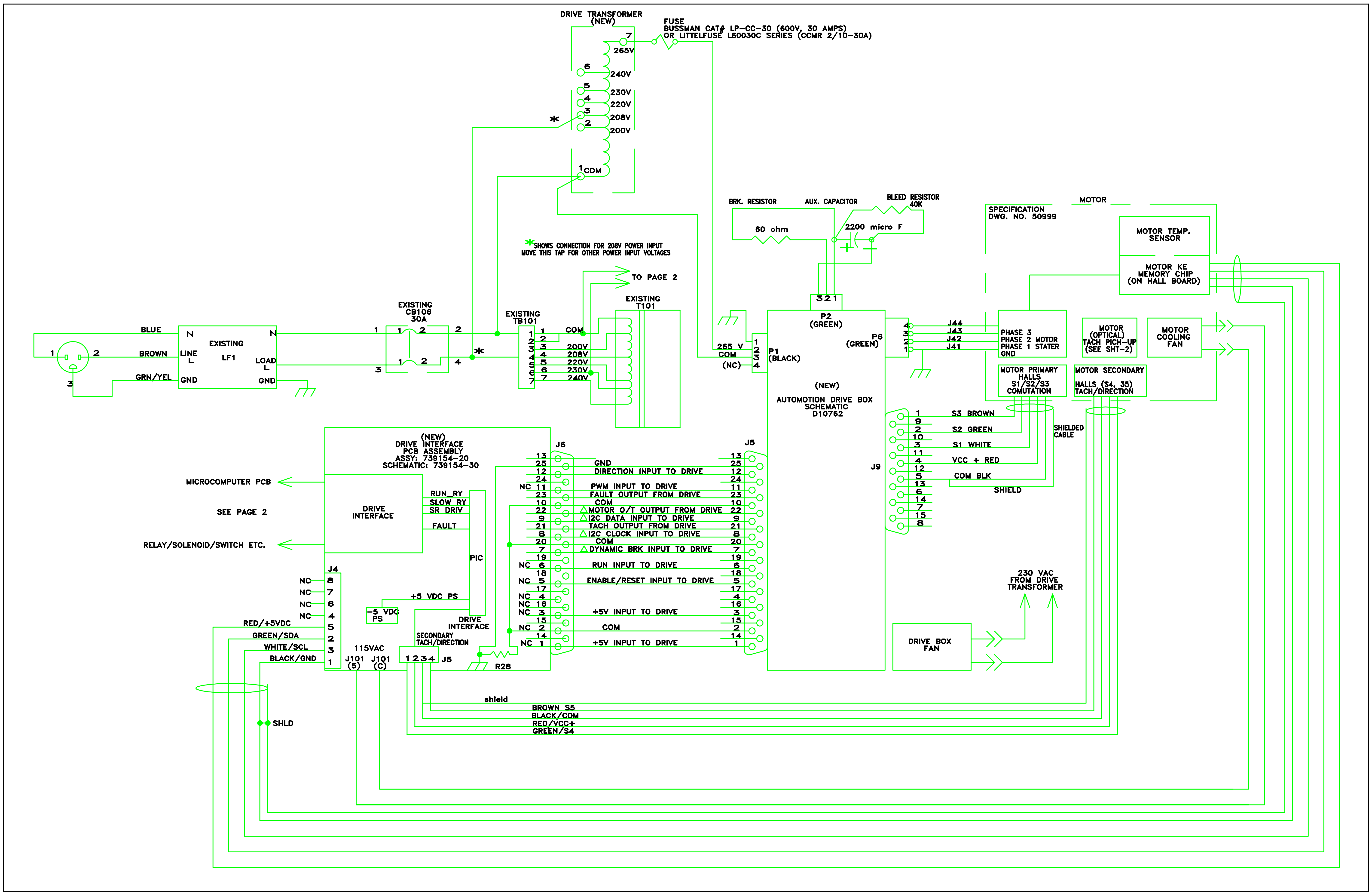
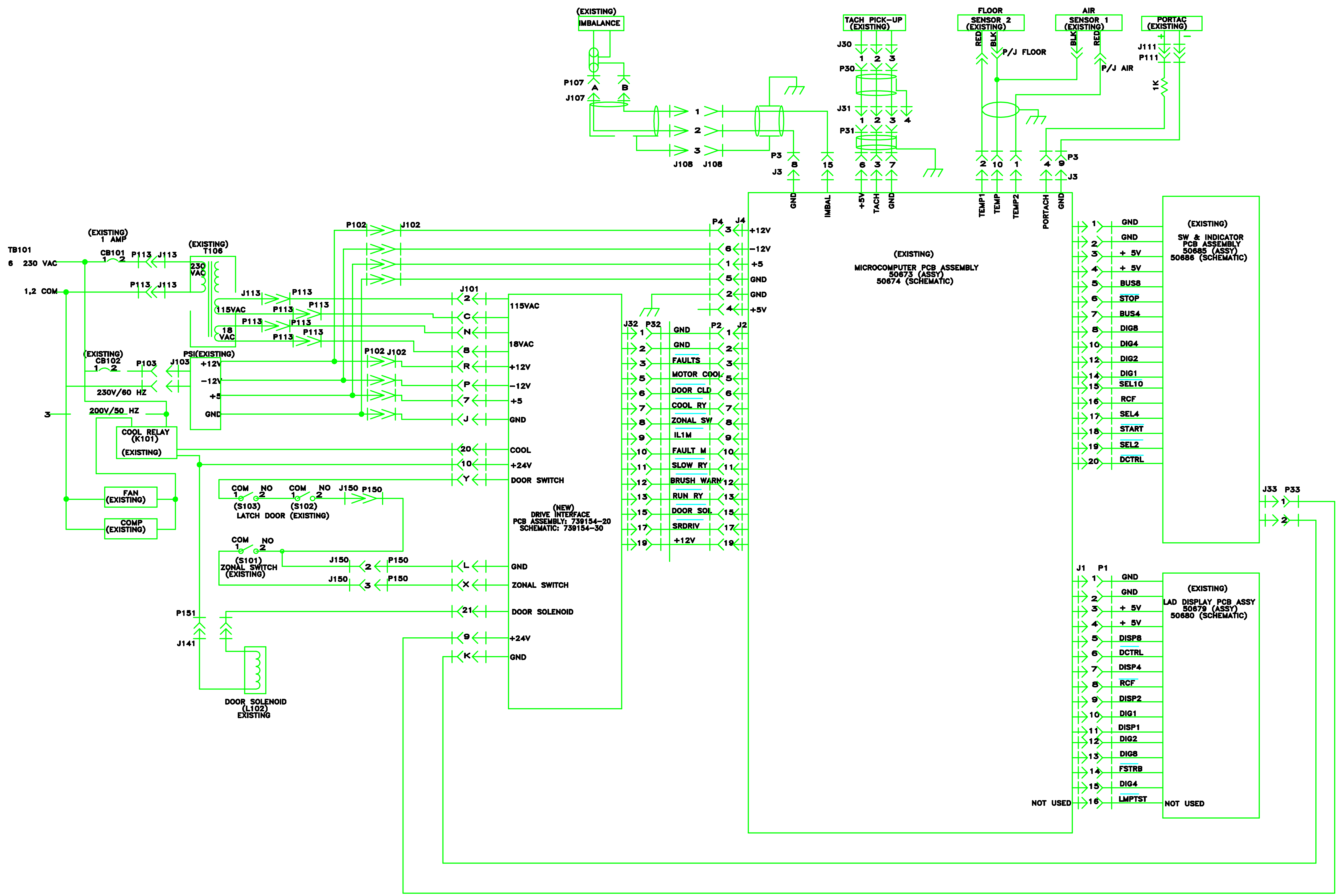
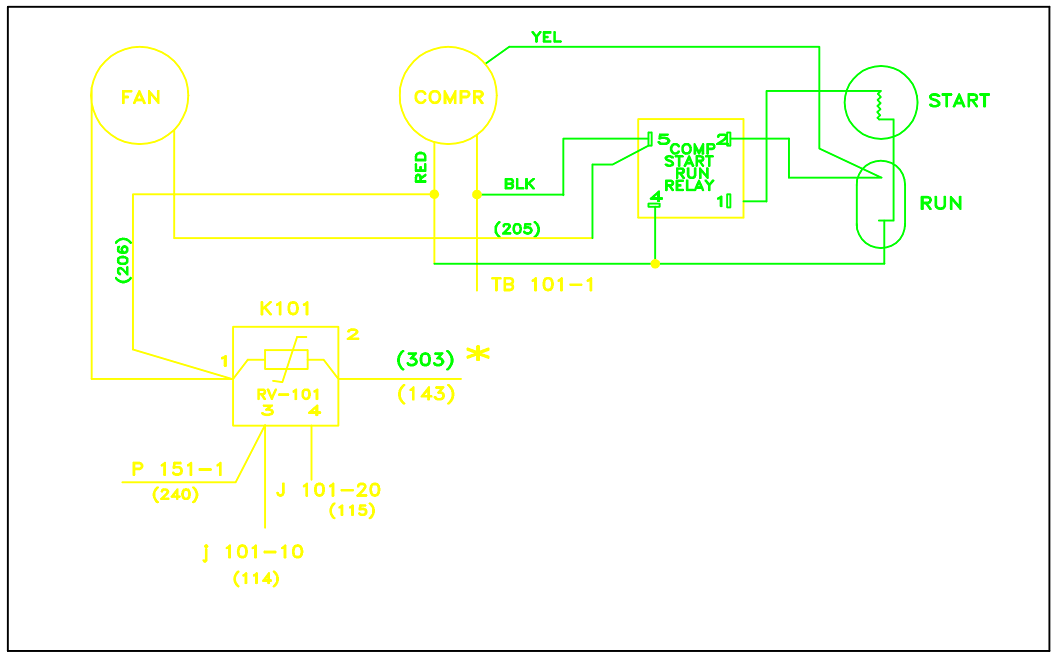


Figure 6-2. RC-5C PLUS Wiring Diagram (Sheet 2 of 2)

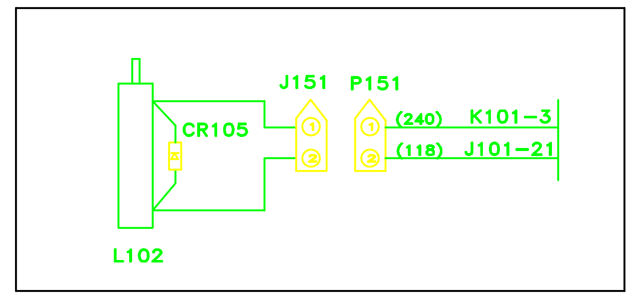


DRIVE TRANSFORMER (NEW)
FUSE
BUSSMAN CAT# LP-CC-30 (600V, 30 AMPS)
OR LITTELFUSE L60030C SERIES (CCMR 2/10-30A)
265V
240V
230V
220V
208V
200V
COM
*SHOWS CONNECTION FOR 208V POWER INPUT
MOVE THIS TAP FOR OTHER POWER INPUT VOLTAGES
TO PAGE 2
EXISTING T101
EXISTING TB101
EXISTING CB106 30A
BLUE
BROWN
GRN/YEL
EXISTING LF1
LINE
LOAD
GND
BRK. RESISTOR
60 ohm
AUX. CAPACITOR
2200 micro F
BLEED RESISTOR 40K
SPECIFICATION DWG. NO. 50999
MOTOR
MOTOR TEMP. SENSOR
MOTOR KE MEMORY CHIP (ON HALL BOARD)
P2 (GREEN)
P6 (GREEN)
P1 (BLACK)
265 V
COM
(NC)
J44
J43
J42
J41
PHASE 3
PHASE 2 MOTOR
PHASE 1 STATER
GND
MOTOR (OPTICAL) TACH PICH-UP (SEE SHT-2)
MOTOR COOLING FAN
MOTOR PRIMARY HALLS S1/S2/S3 COMUTATION
MOTOR SECONDARY HALLS (S4, 35) TACH/DIRECTION
(NEW) AUTOMOTION DRIVE BOX SCHEMATIC D10762
S3 BROWN
S2 GREEN
S1 WHITE
VCC + RED
COM BLK
SHIELD
SHIELDED CABLE
J9
(NEW) DRIVE INTERFACE PCB ASSEMBLY ASSY: 739154-20 SCHEMATIC: 739154-30
MICROCOMPUTER PCB
SEE PAGE 2
RELAY/SOLENOID/SWITCH ETC.
DRIVE INTERFACE
RUN_RY
SLOW RY
SR DRIV
FAULT
PIC
J6
J5
GND
DIRECTION INPUT TO DRIVE
PWM INPUT TO DRIVE
FAULT OUTPUT FROM DRIVE
COM
MOTOR O/T OUTPUT FROM DRIVE
I2C DATA INPUT TO DRIVE
TACH OUTPUT FROM DRIVE
I2C CLOCK INPUT TO DRIVE
COM
DYNAMIC BRK INPUT TO DRIVE
RUN INPUT TO DRIVE
ENABLE/RESET INPUT TO DRIVE
+5V INPUT TO DRIVE
COM
+5V INPUT TO DRIVE
NC
J4
RED/+5VDC
GREEN/SDA
WHITE/SCL
BLACK/GND
+5 VDC PS
-5 VDC PS
DRIVE INTERFACE SECONDARY TACH/DIRECTION
115VAC
J101 (5)
J101 (C)
R28
SHLD
shield
BROWN S5
BLACK/COM
RED/VCC+
GREEN/S4
230 VAC FROM DRIVE TRANSFORMER
DRIVE BOX FAN

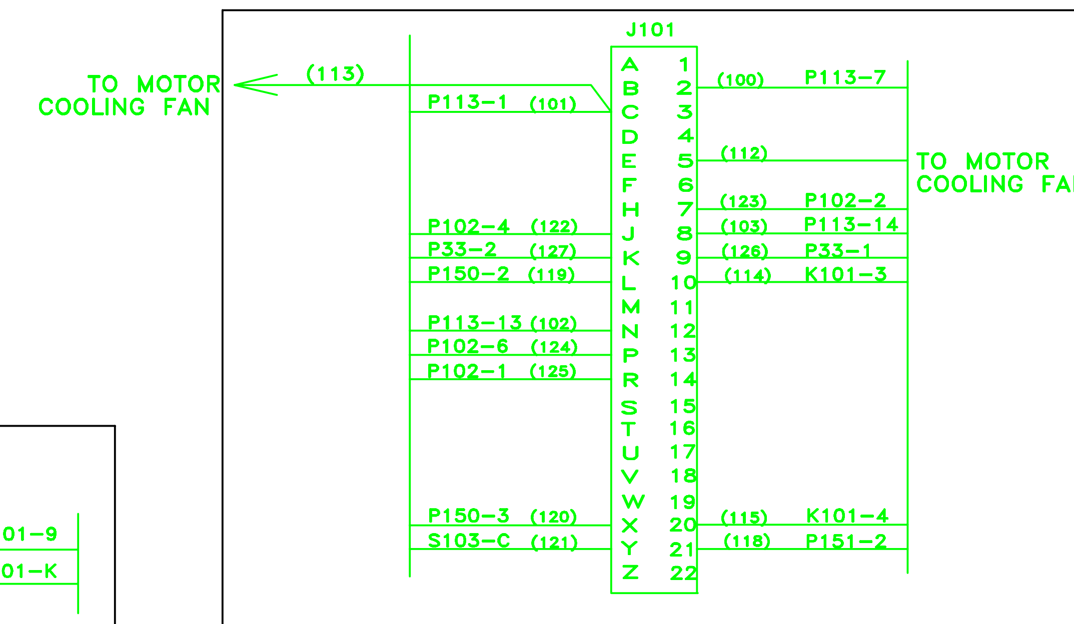

(EXISTING) IMBALANCE
TACH PICK-UP (EXISTING)
FLOOR SENSOR 2 (EXISTING)
AIR SENSOR 1 (EXISTING)
PORTAC (EXISTING)
P/J FLOOR
P/J AIR
(EXISTING) MICROCOMPUTER PCB ASSEMBLY 50673 (ASSY) 50674 (SCHEMATIC)
(EXISTING) SW & INDICATOR PCB ASSEMBLY 50685 (ASSY) 50686 (SCHEMATIC)
(EXISTING) LAD DISPLAY PCB ASSY 50679 (ASSY) 50680 (SCHEMATIC)
(NEW) DRIVE INTERFACE PCB ASSEMBLY: 739154-20 SCHEMATIC: 739154-30
TB101
6 230 VAC
1,2 COM
(EXISTING) 1 AMP CB101
(EXISTING) T106
(EXISTING) CB102
230V/60 HZ
200V/50 HZ
PS1(EXISTING)
COOL RELAY (K101) (EXISTING)
FAN (EXISTING)
COMP (EXISTING)
(S103) LATCH DOOR (S102) (EXISTING)
(S101) ZONAL SWITCH (EXISTING)
DOOR SOLENOID (L102) EXISTING
115VAC
18VAC
+12V
-12V
+5
GND
COOL
+24V
DOOR SWITCH
ZONAL SWITCH
DOOR SOLENOID
FAULTS
MOTOR COOL
DOOR CLD
COOL RY
ZONAL SW
IL1M
FAULT M
SLOW RY
BRUSH WARN
RUN RY
DOOR SOL
SRDRIV
BUS8
STOP
BUS4
DIG8
DIG4
DIG2
DIG1
SEL10
RCF
SEL4
START
SEL2
DCTRL
DISP8
DISP4
DISP2
DISP1
FSTRB
LMPTST
NOT USED
TEMP1
TEMP
TEMP2
PORTACH
IMBAL
TACH



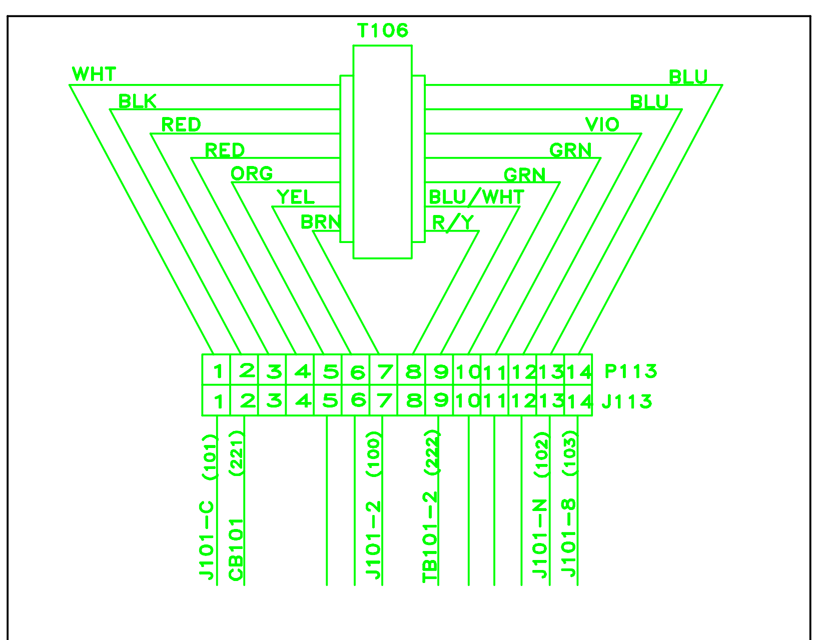
FAN
COMPR
YEL
START
RED
BLK
COMP START RUN RELAY
RUN
(205)
(206)
TB 101-1
K101
(303) *
(143)
RV-101
P 151-1
(240)
J 101-20
(115)
J 101-10
(114)



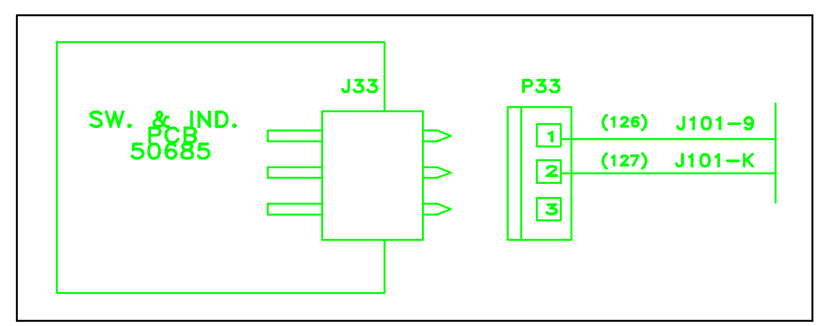
J151
P151
CR105
(240) K101-3
(118) J101-21
L102



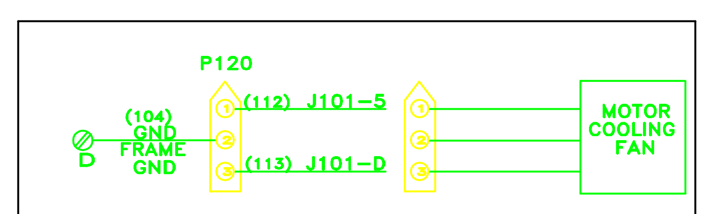
TO MOTOR COOLING FAN
(113)
J101
P113-1 (101)
(100) P113-7
(112)
TO MOTOR COOLING FAN
(123) P102-2
P102-4 (122)
(103) P113-14
P33-2 (127)
(126) P33-1
P150-2 (119)
(114) K101-3
P113-13 (102)
P102-6 (124)
P102-1 (125)
P150-3 (120)
(115) K101-4
S103-C (121)
(118) P151-2



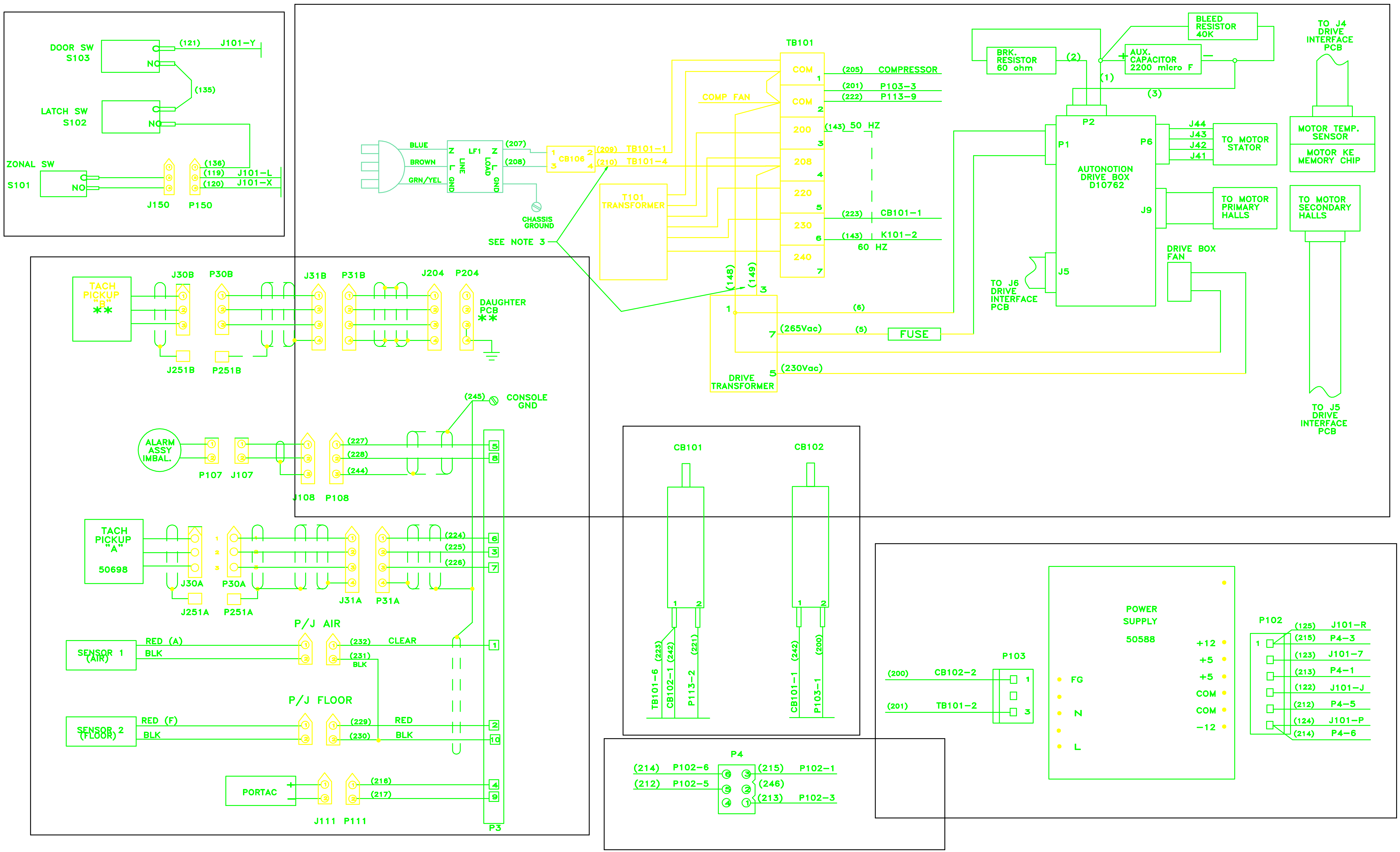
T106
WHT
BLK
RED
RED
ORG
YEL
BRN
BLU
BLU
VIO
GRN
GRN
BLU/WHT
R/Y
P113
J113
J101-C (101)
CB101 (221)
J101-2 (100)
TB101-2 (222)
J101-N (102)
J101-8 (103)



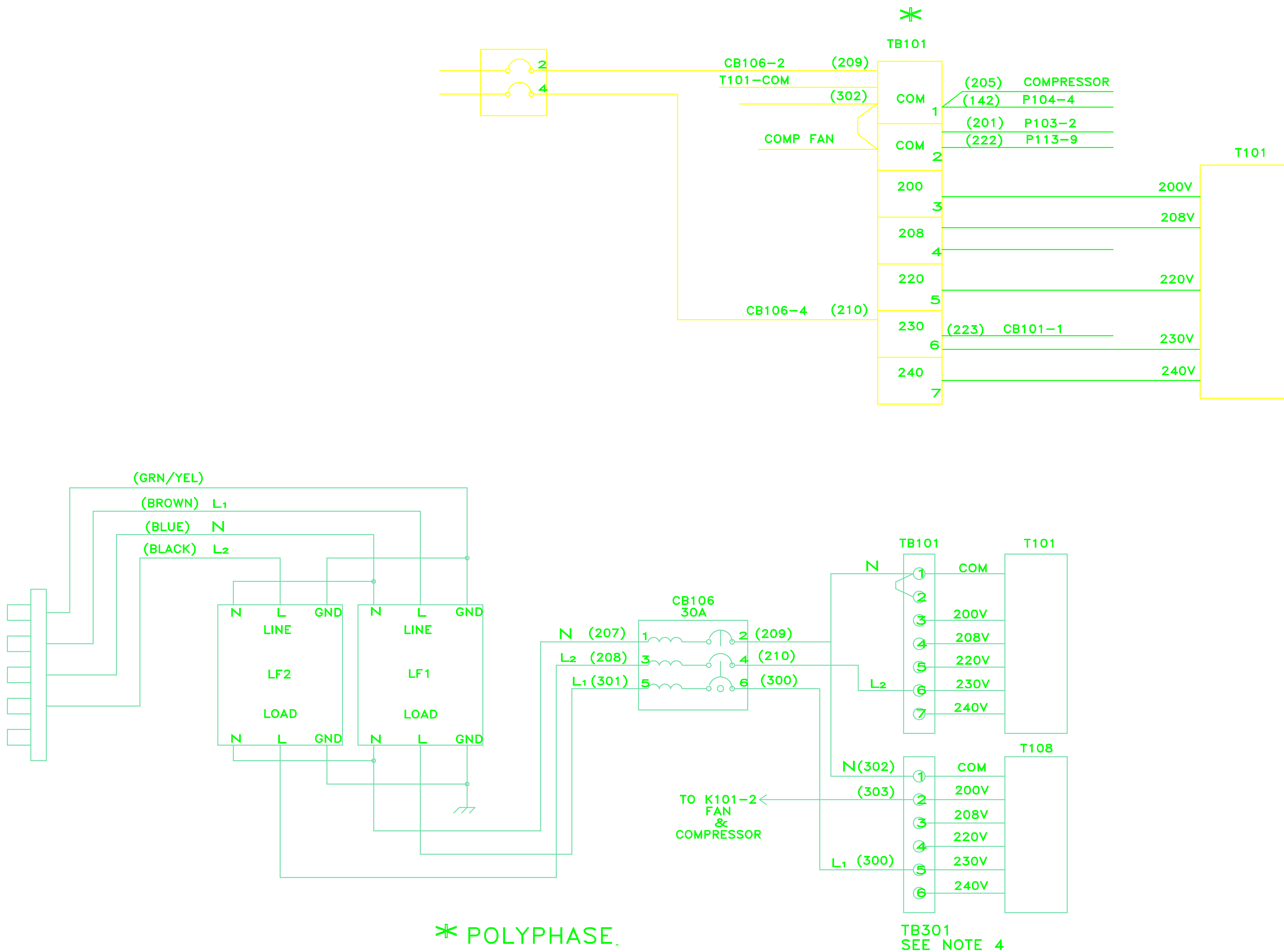
SW. & IND. PCB 50685
J33
P33
(126) J101-9
(127) J101-K



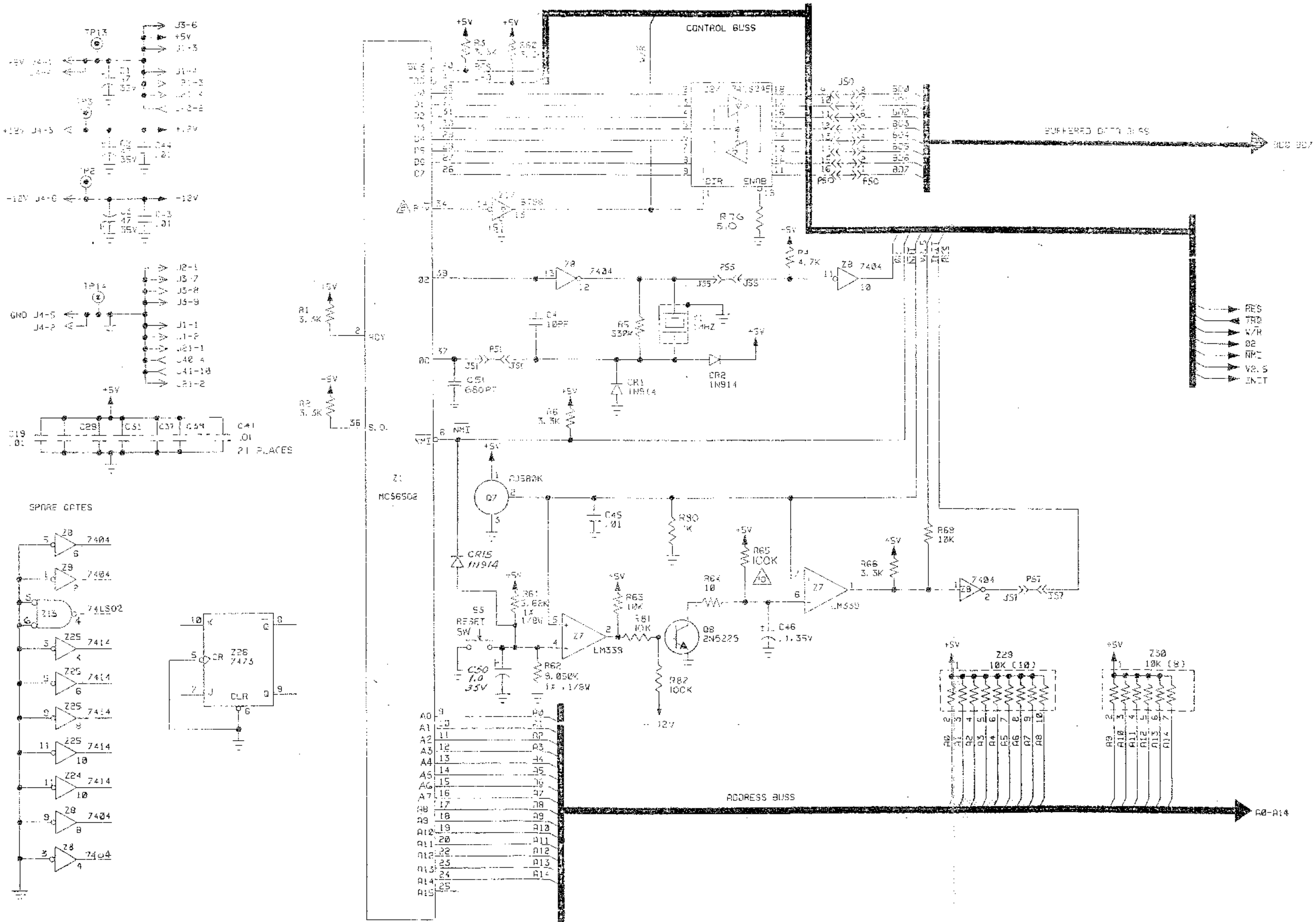
P120
(104) GND
FRAME GND
D
(112) J101-5
(113) J101-D
MOTOR COOLING FAN



DOOR SW S103
LATCH SW S102
ZONAL SW S101
J101-Y
J101-L
J101-X
J150
P150
TB101
COMPRESSOR
P103-3
P113-9
COMP FAN
50 HZ
60 HZ
CB101-1
K101-2
LF1
CB106
TB101-1
TB101-4
T101 TRANSFORMER
CHASSIS GROUND
SEE NOTE 3
BRK. RESISTOR 60 ohm
BLEED RESISTOR 40K
AUX. CAPACITOR 2200 micro F
TO J4 DRIVE INTERFACE PCB
MOTOR TEMP. SENSOR
MOTOR KE MEMORY CHIP
AUTONOTION DRIVE BOX D10762
TO MOTOR STATOR
TO MOTOR PRIMARY HALLS
TO MOTOR SECONDARY HALLS
TO J6 DRIVE INTERFACE PCB
DRIVE BOX FAN
FUSE
DRIVE TRANSFORMER
(265Vac)
(230Vac)
TO J5 DRIVE INTERFACE PCB
TACH PICKUP "B"
DAUGHTER PCB
CONSOLE GND
ALARM ASSY IMBAL.
TACH PICKUP "A" 50698
P/J AIR
P/J FLOOR
SENSOR 1 (AIR)
SENSOR 2 (FLOOR)
PORTAC
P3
CB101
CB102
TB101-6
CB102-1
P113-2
CB101-1
P103-1
P4
P103
POWER SUPPLY 50588
P102


*
TB101
CB106-2
(209)
T101-COM
(302)
COM
1
(205) COMPRESSOR
(142) P104-4
(201) P103-2
(222) P113-9
COMP FAN
COM
2
T101
200
3
200V
208
4
208V
220
5
220V
CB106-4 (210)
230
6
(223) CB101-1
230V
240
7
240V
(GRN/YEL)
(BROWN) L1
(BLUE) N
(BLACK) L2
N L GND
LINE
LF2
LOAD
N L GND
N L GND
LINE
LF1
LOAD
N L GND
CB106
30A
N (207)
L2 (208)
L1 (301)
1 2 (209)
3 4 (210)
5 6 (300)
TB101
T101
N
COM
200V
208V
220V
L2
230V
240V
T108
N(302)
COM
(303)
200V
TO K101-2
FAN
&
COMPRESSOR
208V
220V
L1 (300)
230V
240V
TB301
SEE NOTE 4
* POLYPHASE.

I.C. TABLE					
DESIG.	TYPE	+5V	GND	+12V	-12V
Z1	6502	8	1, 21	—	—
Z2	SPARE	24	12	—	—
Z3	2732	24	12	—	—
Z4	2732	24	12	—	—
Z5	6522	20	1	—	—
Z6	6522	20	1	—	—
Z7	LM339	3	12	—	—
Z8	7404	14	7	—	
Z9	7404	14	7	—	—
Z12	7400	14	7	—	—
Z13	74LS02	14	7	—	—
Z14	74LS138	16	8	—	—
Z15	74LS139	16	8	—	—
Z16	8T97	16	8	—	—
Z17	8T98	16	8	—	—
Z18	8T97	16	8	—	—
Z19	AD7542	14	3, 12	—	—
Z20	CA3162	14	7	—	—
Z21	LM324	—	—	4	11
Z22	LM555	—	4	8	—
Z23	7407	14	7	—	—
Z24	7414	14	7	—	—
Z25	7414	14	7	—	—
Z26	7473	4	11	—	—
Z27	74LS245	20	10	—	—
Z28	74154	24	12	—	—
Z34	ICS565	28	14	—	—



NOTES:
1-UNLESS OTHERWISE SPECIFIED.
A-ALL RESISTORS ARE IN OHMS, AND 1/4W +5%
B-ALL CAPACITORS ARE IN MICROFARADS

Figure 6-3. Schematic for Microcomputer Printed Circuit Board, PN 50674-11 (Sheet 1 of 4)

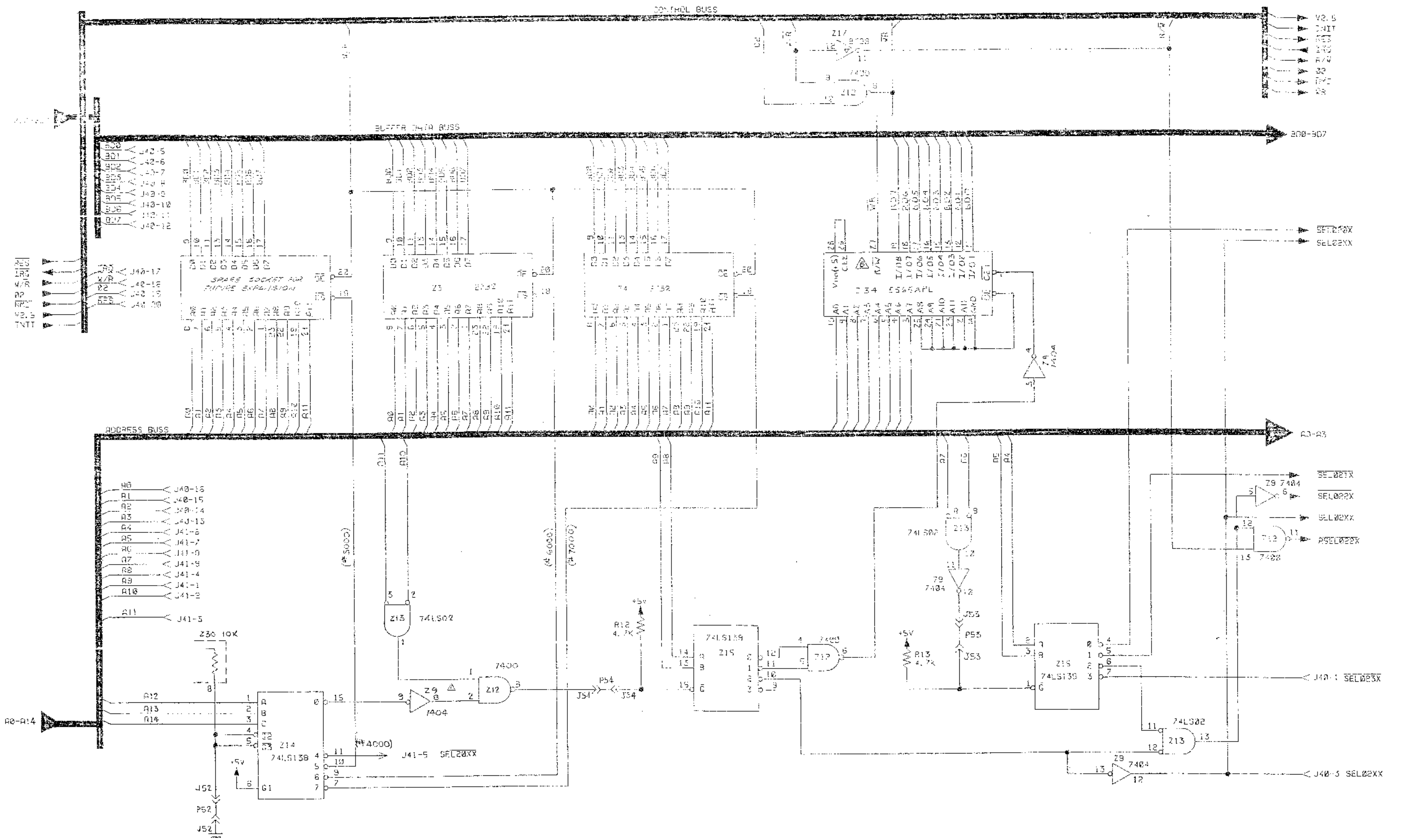


Figure 6-3. Schematic for Microcomputer Printed Circuit Board, PN 50674-11 (Sheet 2 of 4)

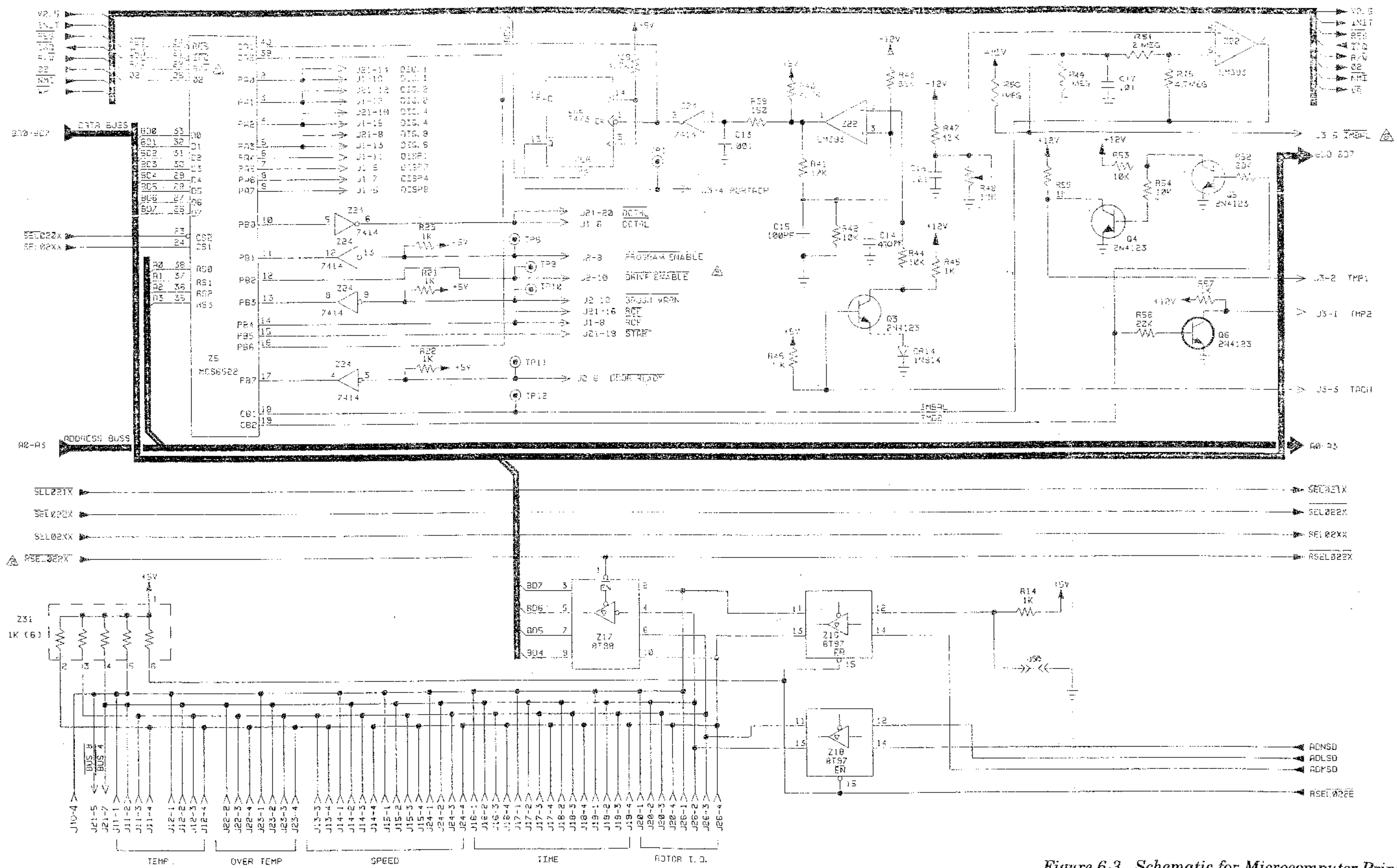


Figure 6-3. Schematic for Microcomputer Printed Circuit Board, PN 50674-11 (Sheet 3 of 4)

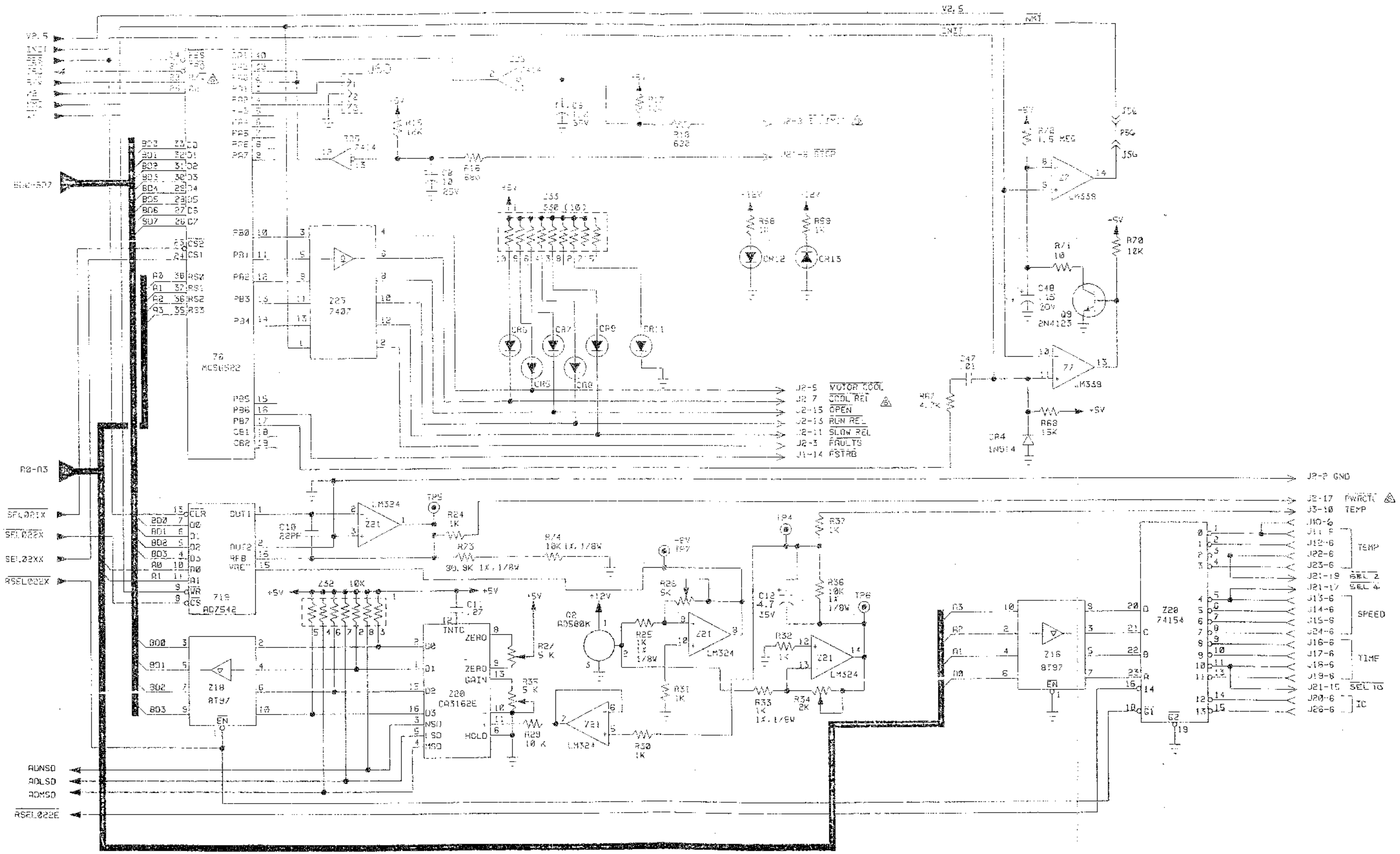


Figure 6-3. Schematic for Microcomputer Printed Circuit Board, PN 50674-11 (Sheet 4 of 4)

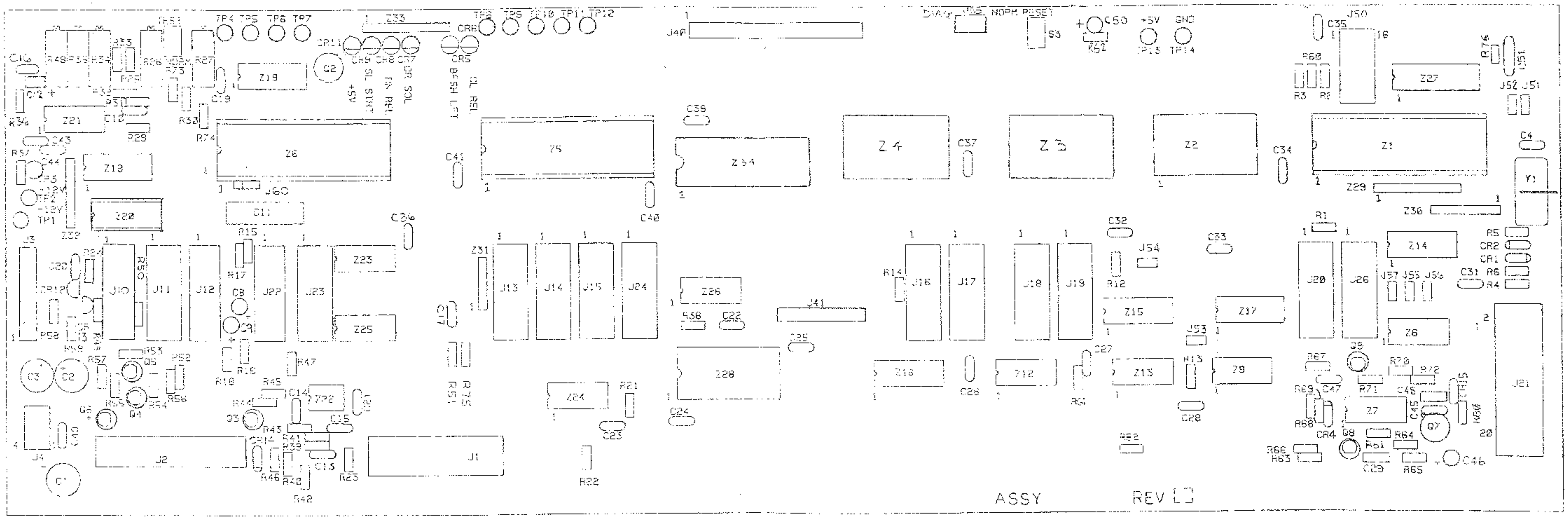


Figure 6-4. Component Location: Microcomputer Printed Circuit Board, PN 74542-0

Table 6-1. Component Description, Microcomputer Printed Circuit Board, PN 74542-0

(refer to figure 6-4)

Component	Description
R1, R2, R3, R6, R60, R66	Resistor, Fixed, Carbon Compound, 3.3 KΩ, 1/4 W, ±5%
R4, R12, R13, R38, R40, R67	Resistor, Fixed, Carbon Compound, 4.7 KΩ, 1/4 W, ±5%
R5	Resistor, Fixed, Carbon Compound, 330 KΩ, 1/4 W, ±5%
R14, R21, R22, R23, R24, R30, R31, R32, R37, R45, R55, R57, R58, R59, R80	Resistor, Fixed, Carbon Compound, 1 KΩ, 1/4 W, ±5%
R15, R17, R47	Resistor, Fixed, Carbon Compound, 12 KΩ, 1/4 W, ±5%
R16, R18	Resistor, Fixed, Carbon Compound, 680 Ω, 1/4 W, ±5%
R25, R33	Resistor, Metal Film, 1 KΩ, 1/8 W, 1%
R26, R27, R35	Resistor, Variable, Cermet, 5 KΩ, P.C. Type
R29, R41, R42, R44, R53, R54, R63, R69, R70, R81	Resistor, Fixed, Carbon Compound, 10 KΩ, 1/4 W, ±5%
R34	Resistor, Variable, Cermet, 2 KΩ, P.C. Type
R36, R74	Resistor, Metal Film, 10 KΩ, 1/8 W, ±1%
R39	Resistor, Fixed, Carbon Compound, 150 Ω, 1/4 W, ±5%
R43	Resistor, Fixed, Carbon Compound, 8.2 KΩ, 1/4 W, ±5%
R46	Resistor, Carbon Compound, 1 KΩ, 1/4 W, ±5%
R47	Resistor, Fixed, Carbon Compound, 8.2 KΩ, 1/4 W, ±5%
R48	Resistor, Variable, Cermet, 10 KΩ, P.C. Type
R49, R50	Resistor, Fixed, Carbon Compound, 1 MΩ, 1/4 W, ±5%
R51	Resistor, Carbon Compound, 2 MΩ, 1/4 W, 5%

Table 6-1. Component Description, Microcomputer Printed Circuit Board, PN 74542-0
(refer to figure 6-4), continued

Component	Description
R52, R56	Resistor, Fixed, Carbon Compound, 20 KΩ, 1/4 W, ±5%
R61	Resistor, Metal Film, 5.62 KΩ , 1/8 W, 1%
R62	Resistor, Metal Film, 9.09 KΩ , 1/8 W, 1%
R64, R71	Resistor, Fixed, Carbon Compound, 10 KΩ, 1/4 W, ±5%
R65	Resistor, Fixed, Carbon Compound, 100 KΩ, 1/4 W, ±5%
R68	Resistor, Fixed, Carbon Compound, 15 KΩ, 1/4 W, ±5%
R72	Resistor, Fixed, Carbon Compound, 1.5 MΩ, 1/4 W, ±5%
R73	Resistor, Metal Film, 90.9 KΩ, 1/8 W, 1%
R75	Resistor, Fixed, Carbon Compound, 4.7 MΩ, 1/4 W, ±5%
R76	Resistor, Carbon Compound, 510 Ω , 1/4 W, ±5%
R82	Resistor, Carbon Compound, 100 KΩ , 1/4 W, 5%
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14	Terminal, Swage, 2 Turrett, Brass, Silver Plated
Q3, Q4, Q5, Q6, Q9	Transistor, NPN
Q2, Q7	Integrated Circuit, Voltage Ref., Low Drift, 2.5 Volts
Q8	Transistor, NPN, Silicon
CR1, CR2, CR4, CR14, CR15	Diode, Silicon, Switching
CR5, CR6, CR7, CR8, CR9, CR11, CR12, CR13	Diode, Light Emitting, Red
C1, C2, C3	Capacitor, Electrolytic, Aluminum, 47 µF, 35 WVdc
C4	Capacitor, Ceramic Disc, 10 pF, 1000 WVdc

Table 6-1. Component Description, Microcomputer Printed Circuit Board, PN 74542-0
(refer to figure 6-4), continued

Component	Description
C8	Capacitor, Electrolytic, Aluminum, 10 µF, 25 WVdc
C9, C50	Capacitor, Fixed Tantalum, 1.0 µF, 35 WVdc
C10	Capacitor, Ceramic Molded, 22 pF, 200 WVdc
C11	Capacitor, Filmite "E", Pacer, 0.27 µF, 80 WVdc
C12	Capacitor, Fixed Tantalum, 4.7 µF, 35 WVdc
C13	Capacitor, Ceramic Molded, 1000 pF, 200 WVdc
C14	Capacitor, Ceramic Molded, 470 pF, 200 WVdc
C15	Capacitor, Ceramic Molded, 100 pF, 200 WVdc
C16, C17, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C31, C32, C33, C34, C35, C36, C37, C39, C40, C41, C43, C44, C45, C47	Capacitor, Ceramic Molded, 0.01 µF, 100 WVdc
C46	Capacitor, Fixed Tantalum, 0.1 µF, 35 WVdc
C48	Capacitor, Fixed Tantalum, 0.15 µF, 20 WVdc
C51	Capacitor, Ceramic Disc, 680 pF, 1000 WVdc
Y1	Crystal, 1 MHz
S3	Switch, SPST, Mini-Pushbutton, P.C. Type, 0.4 VA Max.
Z1	Integrated Circuit, Microprocessor
Z3	Memory, Programmed, PN 74544
Z4	Memory, Programmed, PN 74543
Z5, Z6	Integrated Circuit, Versatile, Interface Adapter
Z7	Integrated Circuit, Analog, Quad Comparator

Table 6-1. Component Description, Microcomputer Printed Circuit Board, PN 74542-0
(refer to figure 6-4), continued

Component	Description
Z8, Z9	Integrated Circuit, Digital, Hex Inverter, T0-116
Z12	Integrated Circuit, Quad 2, InputPositive, NAND Gate, 14-pin
Z13	Integrated Circuit, Quad 2, Input Positive, NOR Gate, 14-pin DIP
Z14	Integrated Circuit, Decoder/Demultiplexer, 16-pin DIP
Z15	Integrated Circuit, Decoder/Demultiplexer, 16-pin DIP
Z16, Z18	Integrated Circuit, High Speed, Hex Tri-State Buffer
Z17	Integrated Circuit, High Speed, Hex Tri-State Inverter
Z19	Integrated Circuit, 12-Bit, CMOS Multiplying DAC
Z20	Integrated Circuit, Analog/Digital Converter, Dual In-Line
Z21	Integrated Circuit, Low Power Quad Amplifier
Z22	Integrated Circuit, Dual Differential Comparator
Z23	Integrated Circuit, High Voltage Output, Hex BFR/DRVR with Open Coll
Z24	Integrated Circuit, Hex Schmitt-Trigger Inverter
Z25	Integrated Circuit, Hex Schmitt
Z26	Integrated Circuit, Dual J—K, Master Slave Flip-Flop, 14-pin DIP
Z27	Integrated Circuit, Octal Bustransceiver, 20-pin DIP
Z28	Integrated Circuit, 4 Line to 6 Line, Decoder/Demultiplexers
Z29	Resistor, Network, 10-pin, SIP, 10 K, 1.25 W
Z30, Z32	Resistor, Network, 8-pin, SIP, 10 K, 1.0 W

Table 6-1. Component Description, Microcomputer Printed Circuit Board, PN 74542-0
(refer to figure 6-4), continued

Component	Description
Z31	Resistor, Network, 6-pin, SIP, 1.0 K, 0.75 W
Z33	Resistor, Network, 10-pin, SIP, 330 Ω, 1.25 W
Z34	Integrated Circuit, CMOS, 8K x 8, Static RAM
J1	Connector, P.C., Right Angle, Low Profile, EJCTR, HDR, 16 Position
J2, J21	Connector, P.C., Right Angle, Low Profile, EJCTR, HDR, 20 Position
J3	Connector, Polarizing & Locking Wafer, 10 Contacts
J4	Connector, Plug, Elec, 6 Position
J10, J11, J12, J13, J14, J15, J16, J17, J18, J19, J20, J22, J23, J24, J26	Connector, P.C., Card Edge, 6 Position
J40	Connector, P.C., Top Entry, 20 Position
J41	Connector, P.C., Top Entry, 10 Position
J50	Socket, I.C., Low Profile, 16-pin
J51, J52, J53, J54, J55, J56, J57	Connector, Square Pin, Straight Wafer, 2 Contact
J58, J60	Connector, P.C., Vertical, Center Wafer, 3 Position, Male
P50	Shunt, Programmable, Dual In-Line Package (DIP) Standard Pressure
P51, P52, P53, P54, P55, P56, P57, P58, P60	Plug, Interconnection, 2 Position

REV.	CR	DATE	CHECKED	DRAWING SHEET NO.	REV.	CR	DATE	CHECKED	DRAWING SHEET NO.
3	71567	OBSOLETE			6	K00830	8/17/01	BM	
4	PROTO	5/02/01	BM						
5	K00386	10/3/00	BM						

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Thermo Electron Corporation

275 Aiken Rd.

Asheville, North Carolina

Title

SCHEMATIC, MICROCOMPUTER PCB, 3C/5C

Size	Document Number	Rev
D	74331-30	6

Date: Wednesday, August 29, 2001 — Sheet 1 of 2


TEMP
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Thermo Electron Corporation
275 Aiken Rd.
Asheville, North Carolina
Title
SCHEMATIC, MICROCOMPUTER PCB, 3C/5C
Size D
Document Number 74331-30
Rev 6
Date: Wednesday, August 29, 2001
Sheet 2 of 2

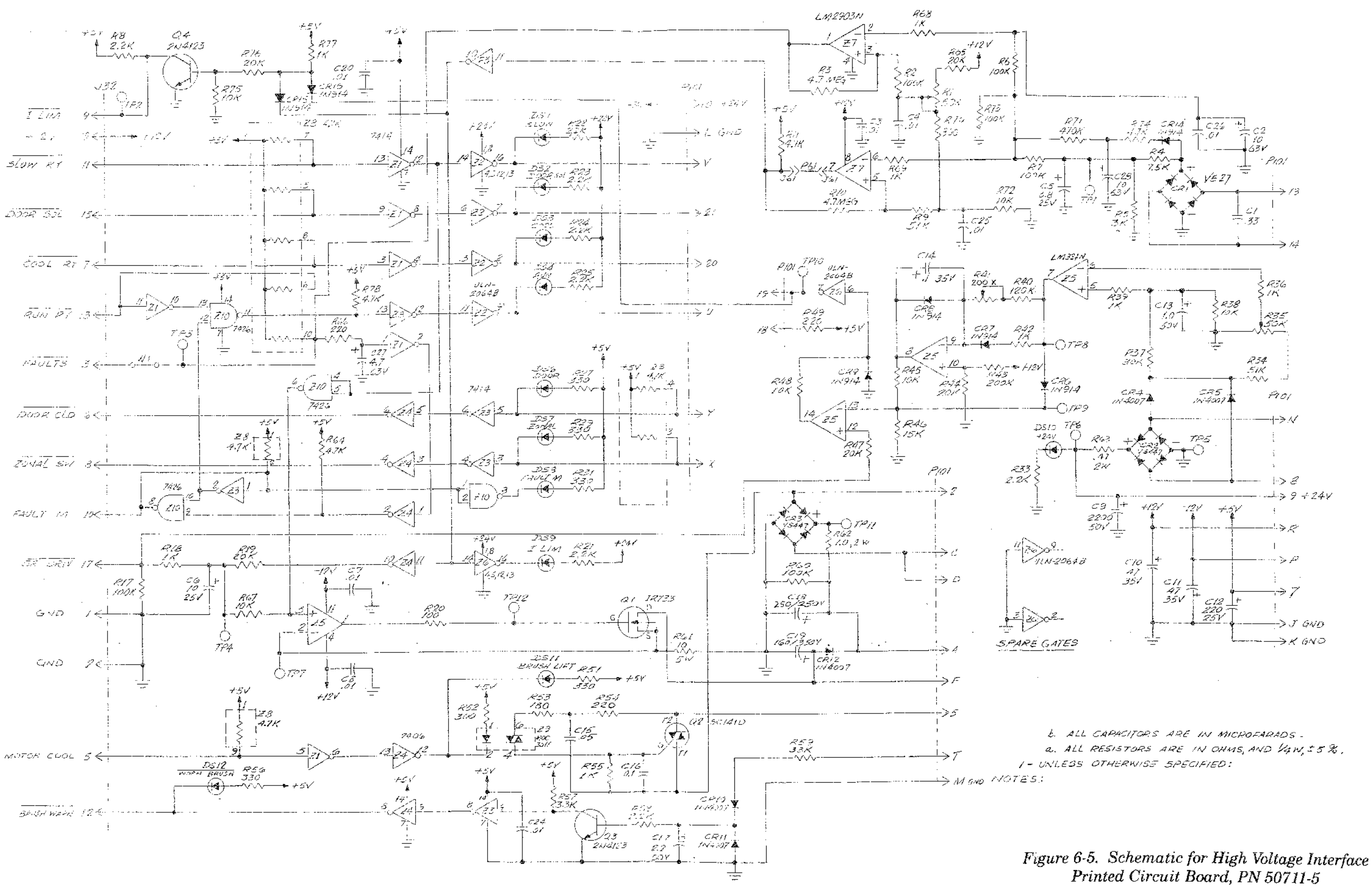


Figure 6-5. Schematic for High Voltage Interface Printed Circuit Board, PN 50711-5

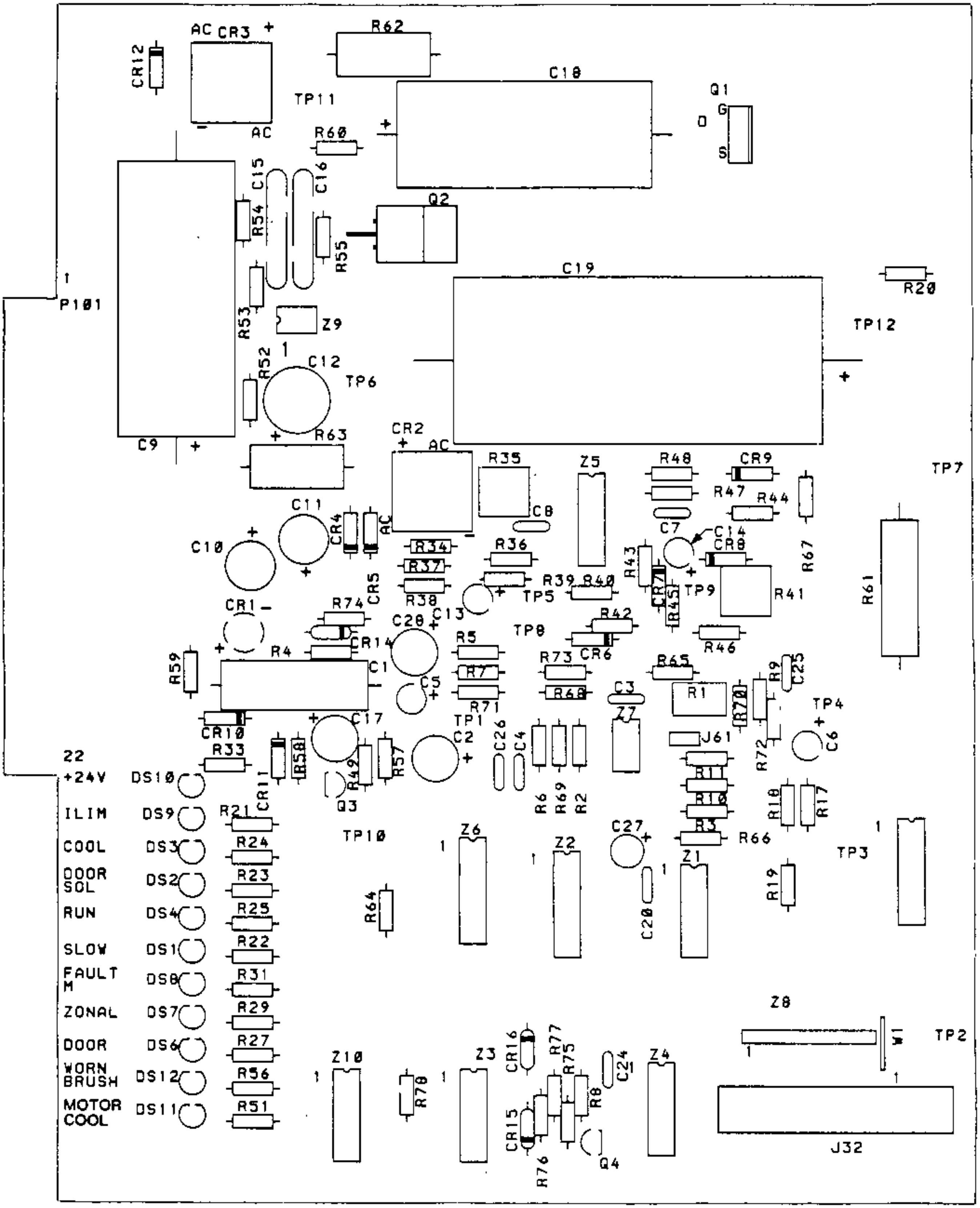


Figure 6-6. Component Location: High Voltage Interface Printed Circuit Board, PN 50710-5

Table 6-2. Component Description, High Voltage Interface Printed Circuit Board, PN 50710-5
(refer to figure 6-6)

Component	Description
R1	Resistor, Variable, Cermet, P.C. Type, 50KΩ
R2, R6, R7, R17, R60, R73	Resistor, Carbon Compound, 100 KΩ, 1/4 W, ±5%
R3, R10	Resistor, Carbon Compound, 4.7 MΩ, 1/4 W, ±5%
R4	Resistor, Carbon Compound, 7500 Ω, 1/4 W, ±5%
R5	Resistor, Carbon Compound, 3000 Ω, 1/4 W, ±5%
R8, R21, R22, R23 R24, R25, R33, R58	Resistor, Carbon Compound, 2.2K Ω, 1/4 W, ±5%
R9, R34	Resistor, Carbon Compound, 51 K Ω, 1/4 W, ±5%
R11, R64, R74, R78	Resistor, Carbon Compound, 4700 Ω, 1/4 W, ±5%
R18, R36, R39, R42, R55, R68, R69, R77	Resistor, Carbon Compound, 1000 Ω, 1/4 W, ±5%
R19,R44, R47, R65 R76	Resistor, Carbon Compound, 20 KΩ, 1/4 W, ±5%
R20	Resistor, Carbon Compound, 100 Ω, 1/4 W, ±5%
R27, R29, R31, R51 R56	Resistor, Carbon Compound, 330 Ω, 1/4 W, ±5%
R35	Resistor, Variable, Cermet, 50 KΩ, P.C. Type
R37	Resistor, Carbon Compound, 30 KΩ, 1/4 W, ±5%
R38, R45, R48, R67, R72, R75	Resistor, Carbon Compound, 10 KΩ, 1/4 W, ±5%
R40	Resistor, Carbon Compound, 120 KΩ 1/4 W, ±5%
R41	Resistor, Variable, Cermet, 200 KΩ, P.C. Type
R43	Resistor, Carbon Compound, 200 KΩ, 1/4 W, ±5%
R46	Resistor, Carbon Compound, 15 KΩ, 1/4 W, ±5%

Table 6-2. Component Description, High Voltage Interface Printed Circuit Board, PN 50710-5
(refer to figure 6-6), continued

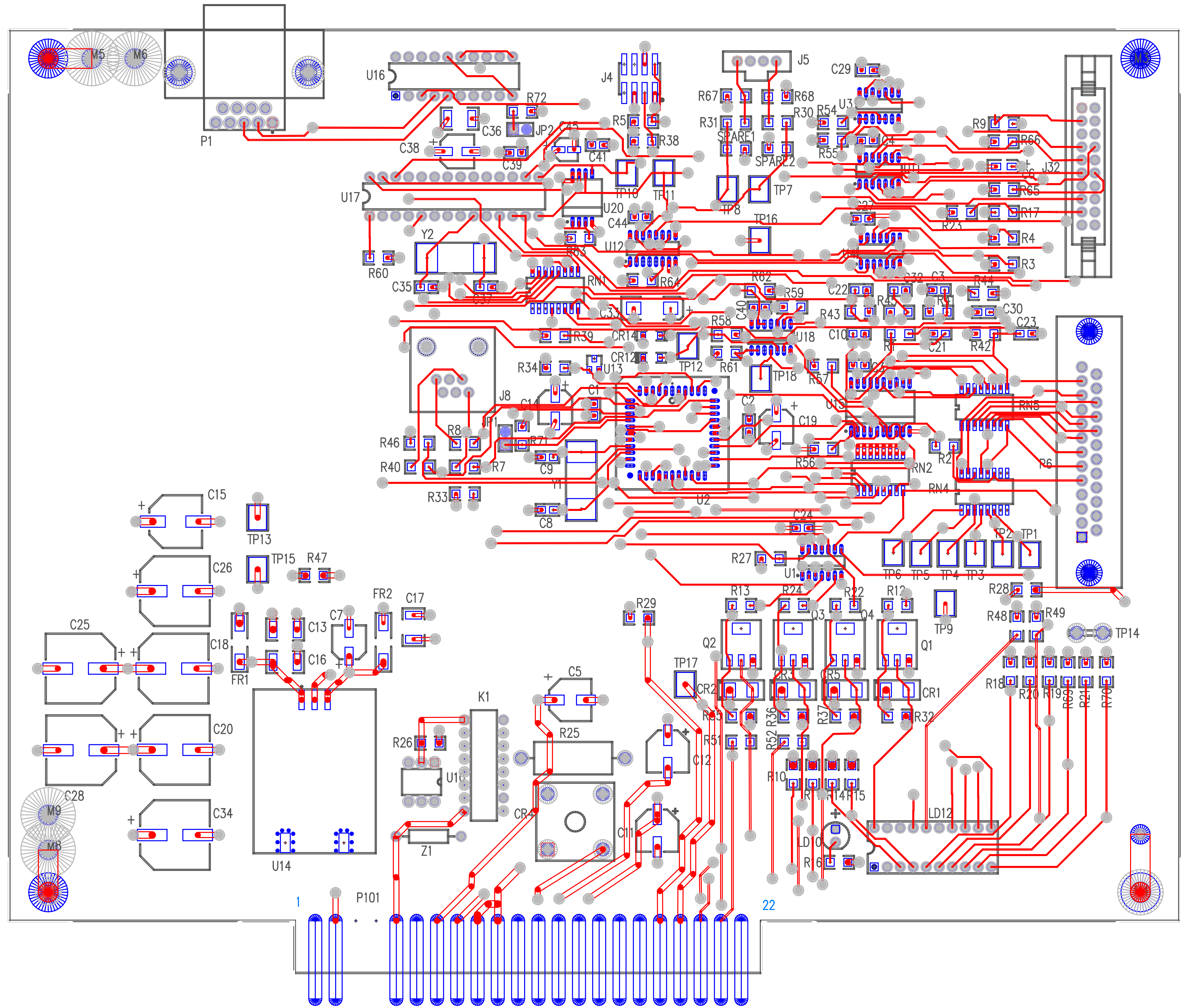
Component	Description
R49, R54, R66	Resistor, Carbon Compound, 220 Ω, 1/4 W, ±5%
R52	Resistor, Carbon Compound, 300 Ω, 1/4 W, ±5%
R53	Resistor, Carbon Compound, 180 Ω, 1/4 W, ±5%
R57	Resistor, Carbon Compound, 3.3 KΩ, 1/4 W, ±5%
R59	Resistor, Carbon Compound, 33 KΩ, 1/4 W, ±5%
R61	Resistor, Wirewound, 10 Ω, 5 W, ±5%
R62	Resistor, Carbon Compound, 1.0 Ω, 1 W, ±5%
R63	Resistor, Carbon Compound, 0.47 Ω, 2 W, ±5%
R71	Resistor, Carbon Compound, 47 KΩ, 1/4 W, ±5%
C1	Capacitor, Filmite, 33 µF, 50 WVdc
C2, C28	Capacitor, Electrolytic, Aluminum, 10 µF, 63 WVdc
C3, C4, C7, C8 C20, C24, C25, C26	Capacitor, Ceramic Molded, 0.01 µF, 100 WVdc
C5	Capacitor, Electrolytic, Aluminum, 6.8 µF, 25 WVdc
C6	Capacitor, Electrolytic, Aluminum, 10 µF, 25 WVdc
C9	Capacitor, Electrolytic, Aluminum, 2200 µF, 50 WVdc
C10, C11	Capacitor, Electrolytic, Aluminum, 47 µF, 35 WVdc
C12	Capacitor, Electrolytic, Aluminum, 220 µF, 25 WVdc
C13	Capacitor, Electrolytic, Aluminum, 1.0 µF, 50 WVdc
C14	Capacitor, Fixed Tantalum, 0.1 µF, 35 WVdc
C15	Capacitor, Ceramic Disc, 0.05 µF, +20%, 500 V
C16	Capacitor, Ceramic Disc, 0.1 µF, 500 WVdc

Table 6-2. Component Description, High Voltage Interface Printed Circuit Board, PN 50710-5
(refer to figure 6-6), continued

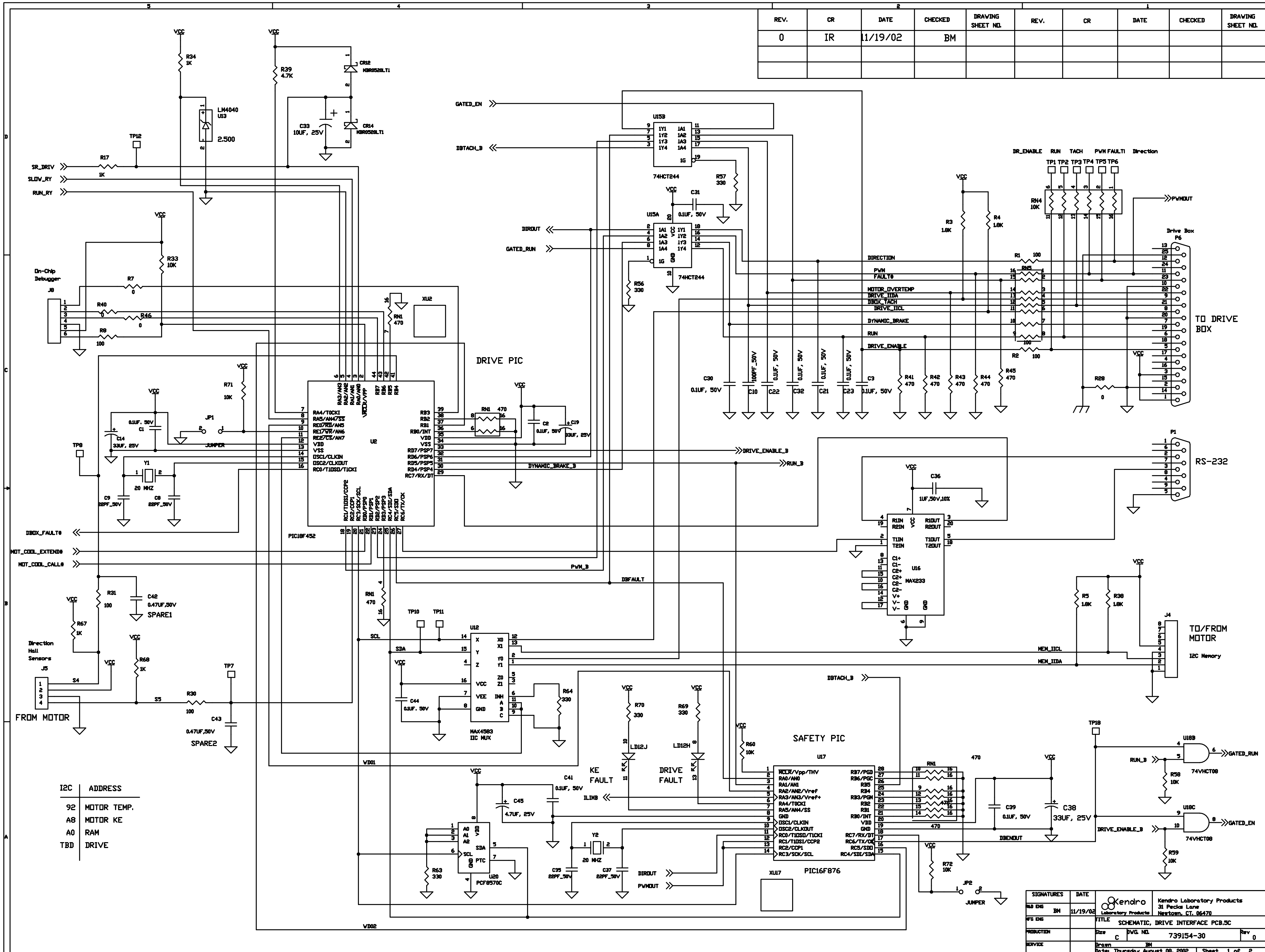
Component	Description
C17	Capacitor, Electrolytic, Aluminum, 2.2 µF, 50 WVdc
C18	Capacitor, Fixed, Electrolytic, Aluminum, 250 µF, 250 WVdc, -10 +50%
C19	Capacitor, Electrolytic, Type TVA, 1650 µF, 350 WVdc
C27	Capacitor, Electrolytic, Aluminum, 4.72 µF, 63 WVdc
CR1	Rectifier, Bridge, Epoxy, 220 V, 1 Amp
CR2	Rectifier, Bridge
CR4, CR5, CR10, CR11, CR12	Diode, IN4007
CR6, CR7, CR8, CR9, CR14, CR15, CR16	Diode, Signal, Silicon
DS1, DS2, DS3, DS4, DS6, DS7, DS8, DS9, DS10, DS11, DS12	Lamp, Indicator, Red
J32	Connector, P.C., STR Pin, Low Profile Ejctr. Hdr., 20 position
J61	Connector, Square Pin, Straight Wafer, 2 Contact
P61	Plug Interconnection, 2 position
Q1	Transistor Power Mosfet, I.R.
Q2	Triac
Q3, Q4	Transistor, NPN
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12	Terminal, Swage, 2 Turret, Brass, Silver Plated
Z1, Z3	Integrated Circuit, Hex Schmitt-Trigger Inverter
Z2, Z6	Integrated Circuit, Darlington Switch

Table 6-2. Component Description, High Voltage Interface Printed Circuit Board, PN 50710-5
(refer to figure 6-6), continued

Component	Description
Z4	Integrated Circuit, Hex Inverter Buffers/Drivers
Z5	Integrated Circuit, Low Power Quad Amp
Z7	Integrated Circuit, Low Power, Low Offset Voltage, Dual Comparator
Z8	Resistor Network, SIP, 10-pin, 4.7 K
Z9	Integrated Circuit, Triac Driver, Optically Isolated
Z10	Integrated Circuit, Quad 2 Input H.V. Intfc., Pos NAND Gates



P1
U16
U17
J4
J5
J8
J32
P101
K1
U14
Y1
Y2
U2
LD12
TP14



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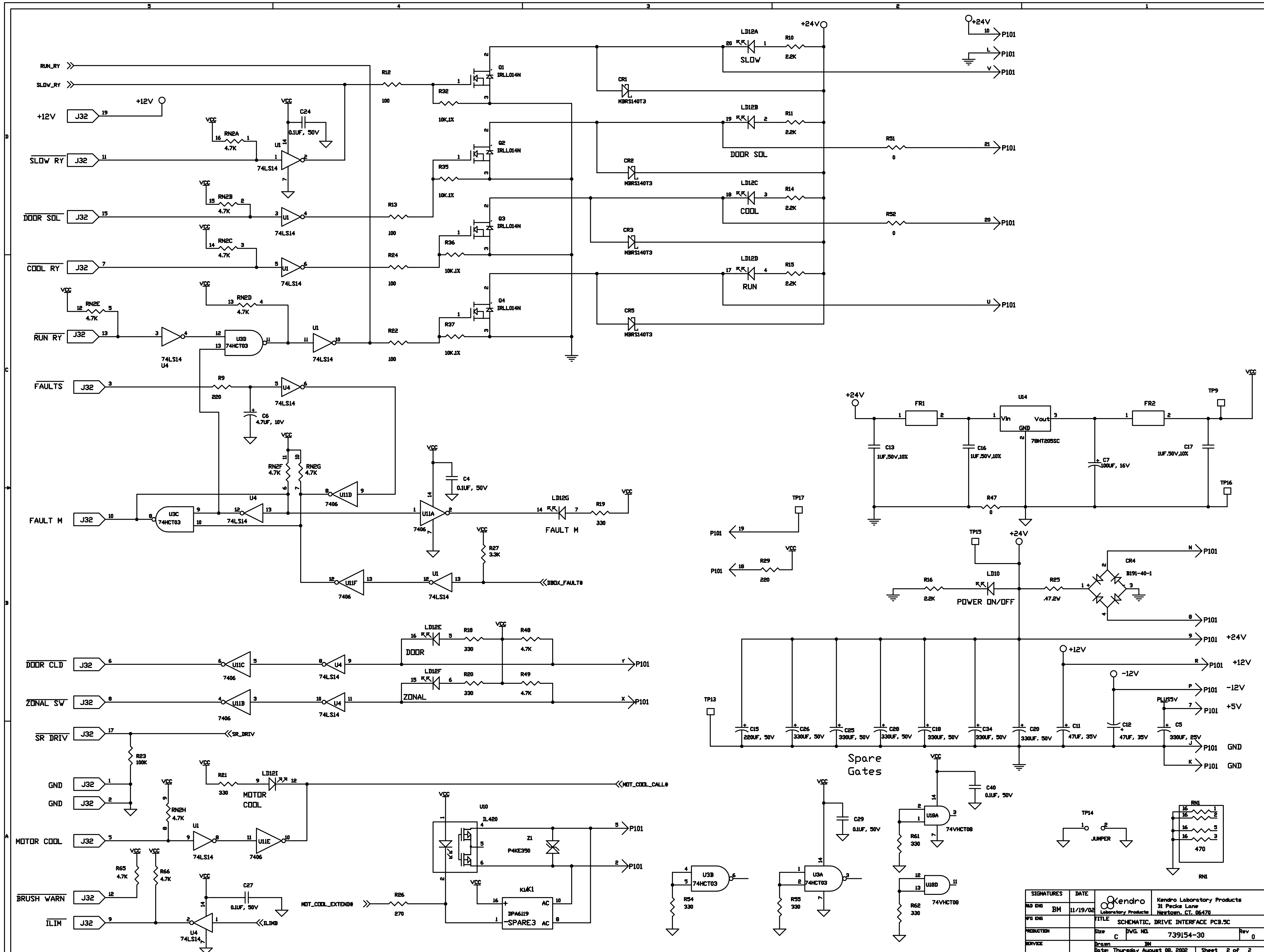
PIC18F452
SAFETY PIC
PIC16F876
TO DRIVE BOX
RS-232
TO/FROM MOTOR
I2C Memory
FROM MOTOR
On-Chip Debugger
Direction Hall Sensors
KE FAULT
DRIVE FAULT
SPARE1
SPARE2
MAX4583 I2C MUX
MAX233
PCF8570C
74HCT244
74VHCT08
LM4040
SR_DRIV
SLOW_RY
RUN_RY
GATED_EN
DBTACH_B
DIROUT
GATED_RUN
DBOX_FAULT#
MOT_COOL_EXTEND#
MOT_COOL_CALL#
DRIVE_ENABLE_B
RUN_B
DYNAMIC_BRAKE_B
PWMOUT
I2C | ADDRESS
92 | MOTOR TEMP.
A8 | MOTOR KE
A0 | RAM
TBD | DRIVE
Kendro Laboratory Products
31 Pecks Lane
Newtown, CT. 06470
TITLE SCHEMATIC, DRIVE INTERFACE PCB.5C
Size C
DWG. NO. 739154-30
Rev 0
Drawn BM
Date: Thursday August 08, 2002
Sheet 1 of 2


Kendro Laboratory Products
31 Pecks Lane
Newtown, CT. 06470
SCHEMATIC, DRIVE INTERFACE PCB.5C
739154-30
Date: Thursday August 08, 2002
Sheet 2 of 2
Spare Gates

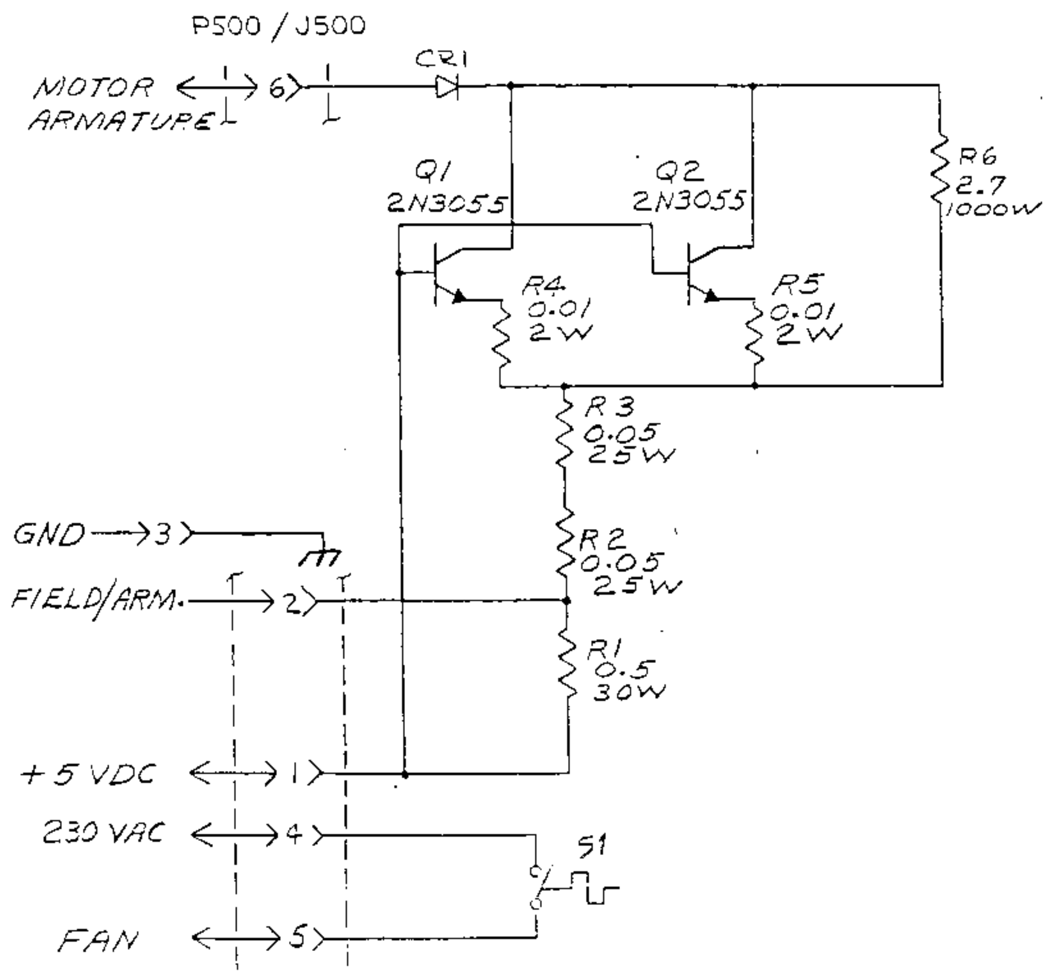


Figure 6-7. Schematic for Constant Current Brake, PN 50816-1

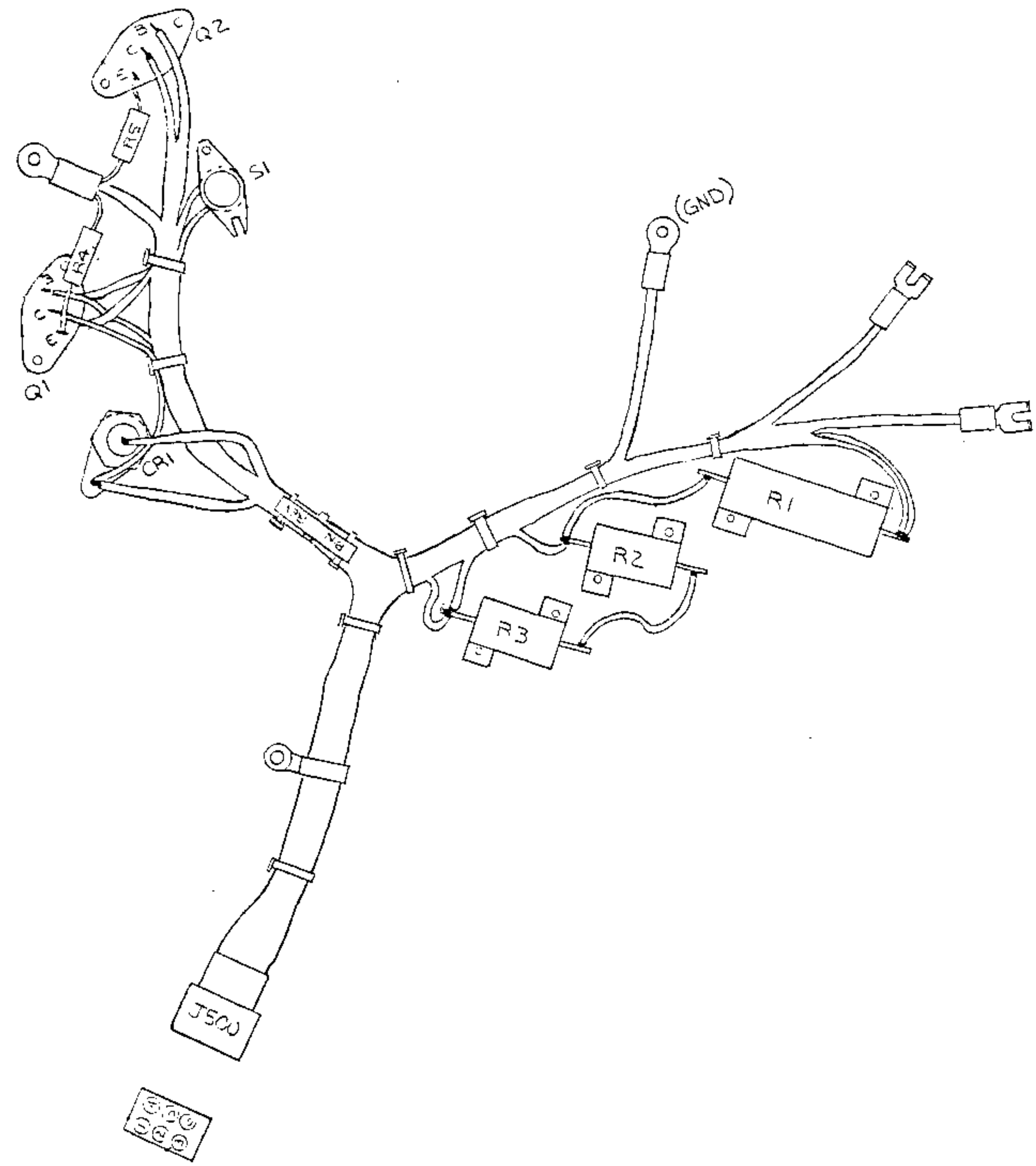
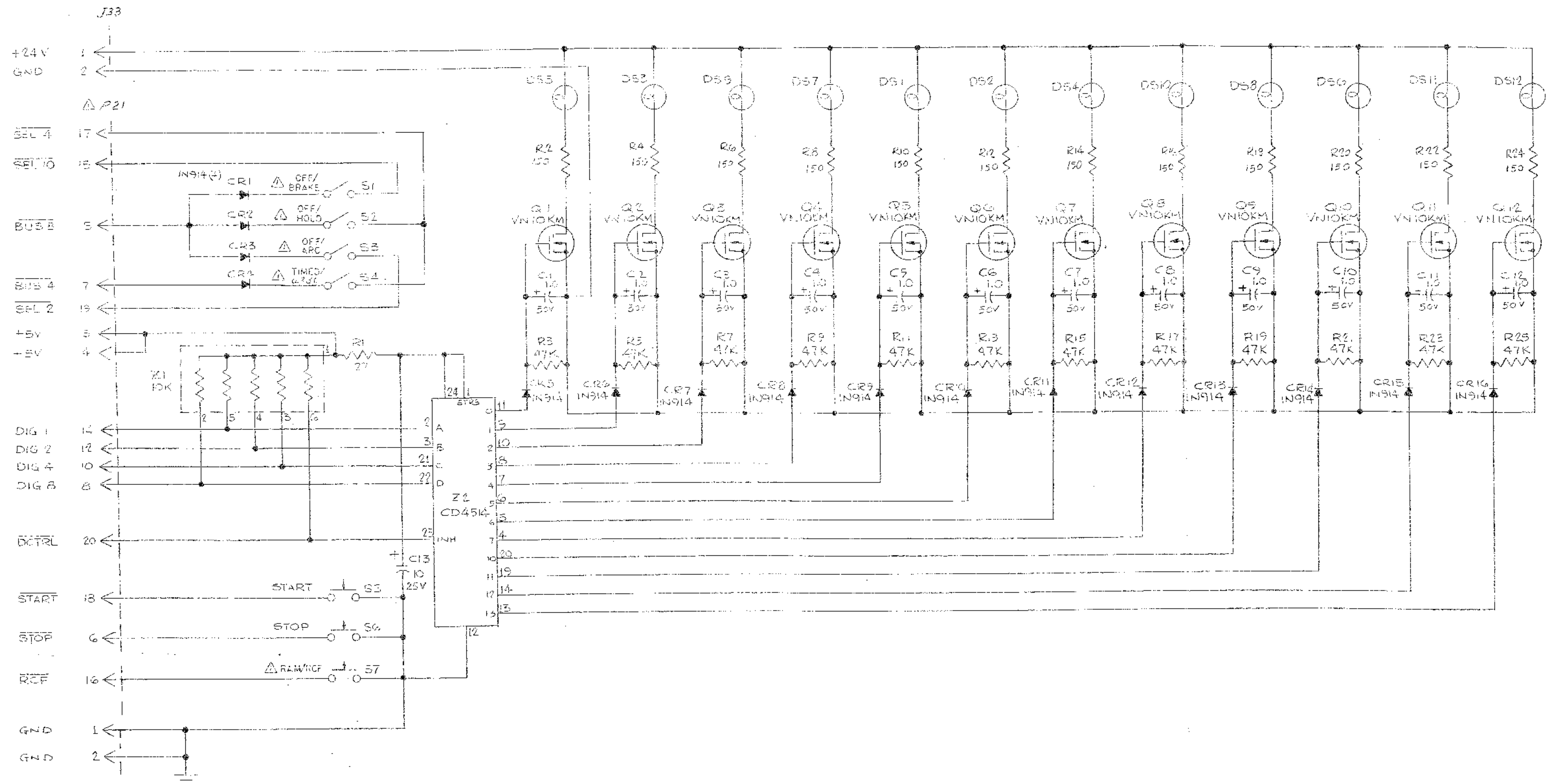


Figure 6-8. Component Location: Constant Current Brake Harness Assembly, PN 50774-6

Table 6-3. Component Description, Constant Current Brake Harness Assembly, PN 50774-6
(refer to figure 6-8), continued

Component	Description
S1	Thermostat, Non-Hermetic Open 112°F, Close 122°F
R1	Resistor, Wirewound, 0.5 Ω, 30 W
R2, R3	Resistor, Wirewound, 0.05 Ω, 25 W
R4, R5	Resistor, Wirewound, 0.10 Ω, 2 W
R6	Resistor, Braking, 2.7 Ω, 100 W
CR1	Rectifier, Silicon, 100 V
Q1, Q2	Transistor, Power NPN
J500	Connector, Body, Receptacle



2. DS1 THRU DS12 LOCATED ON CONSOLE PANEL ASSY PN 50627.
b. ALL CAPACITORS ARE IN MICROFARADS.
a. ALL RESISTORS ARE IN OHMS, 1/4W, ±5%
1. UNLESS OTHERWISE SPECIFIED:
NOTES:

Figure 6-9. Schematic for Switches and Indicators Printed Circuit Board, PN 50686-1

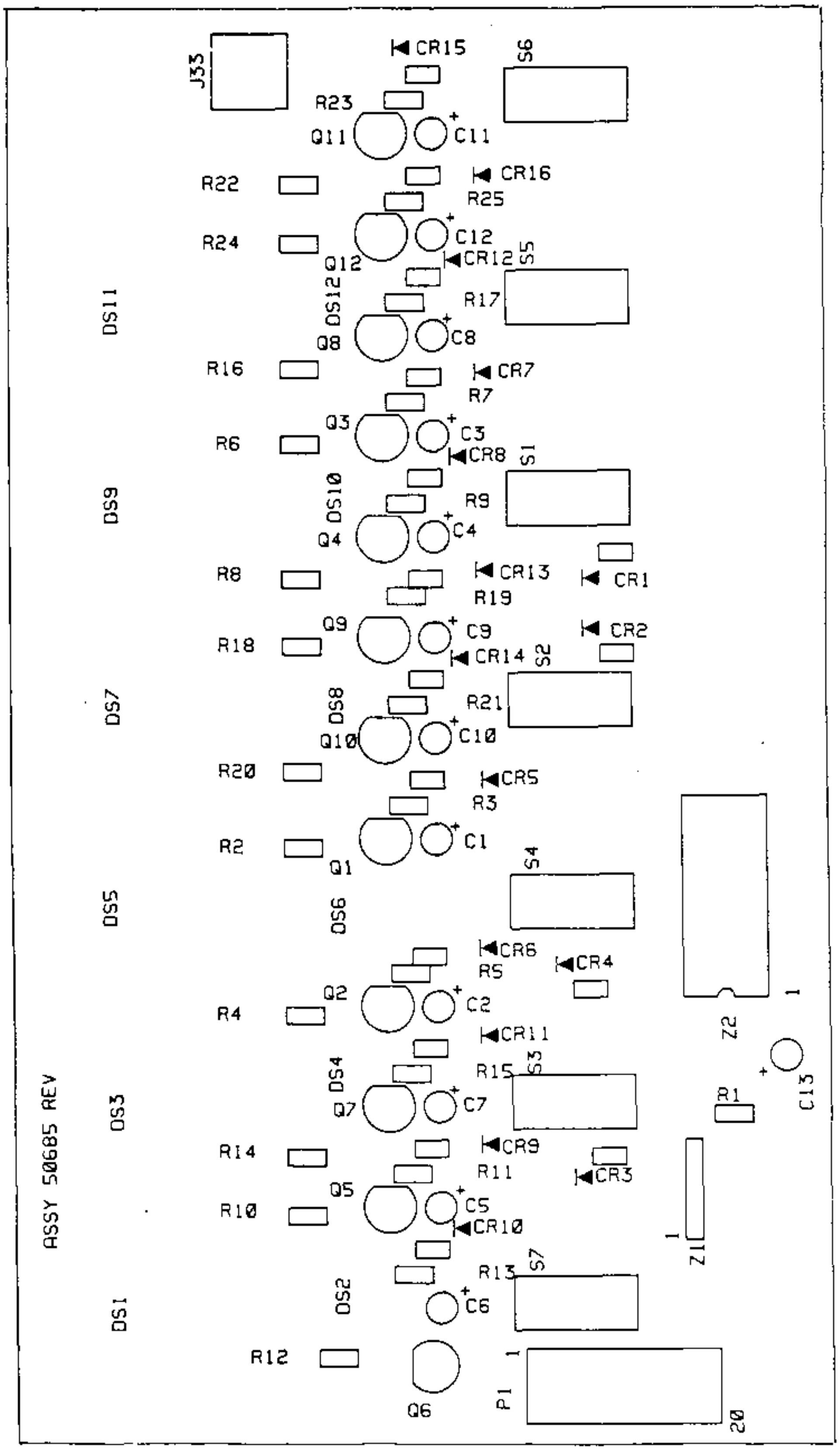
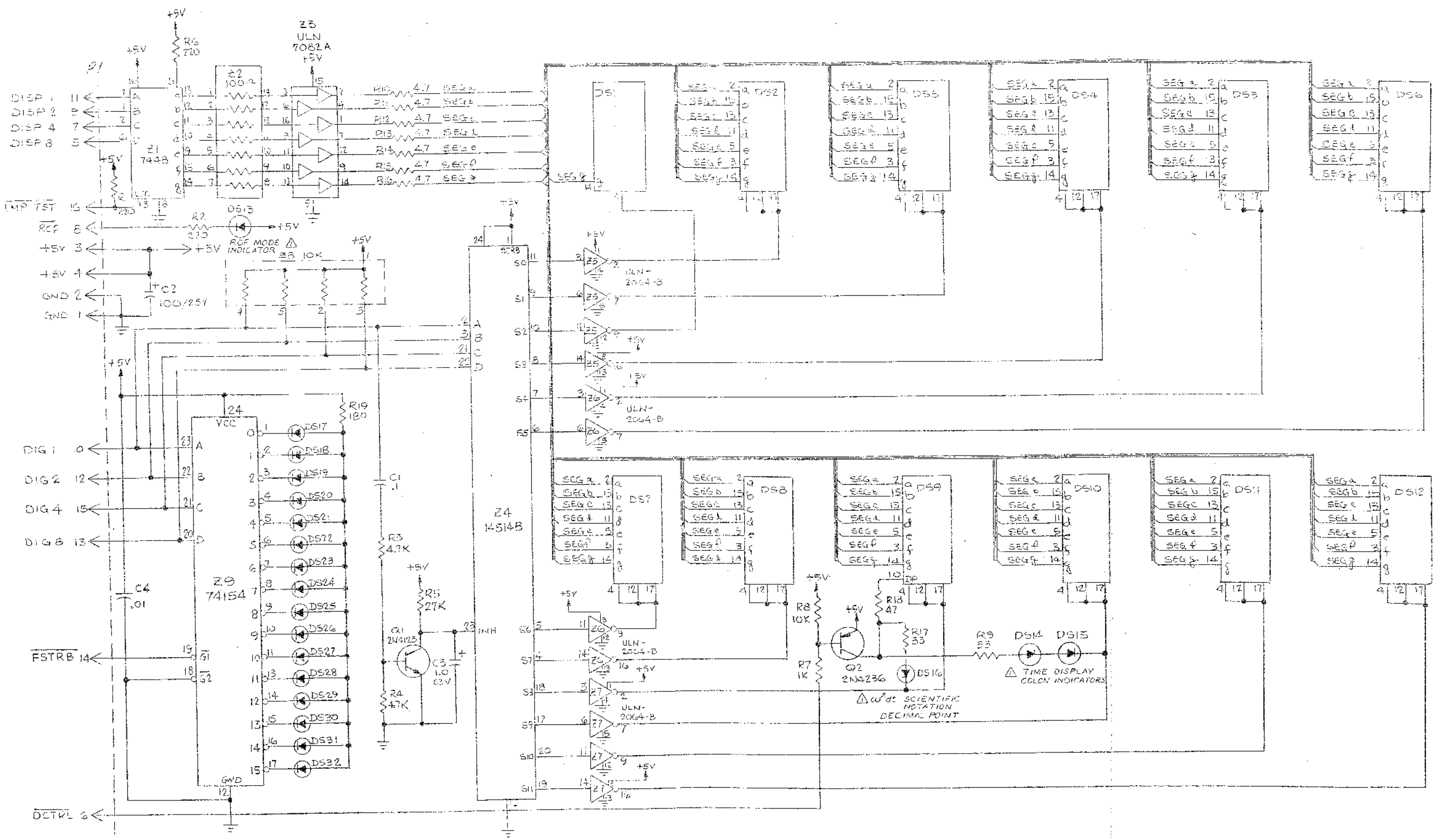


Figure 6-10. Component Location: Switches and Indicators Printed Circuit Board, PN 50685-1

Table 6-4. Component Description, Switches and Indicators Printed Circuit Board, PN 50685-1

(refer to figure 6-10), continued

Component	Description
P1	Connector, P.C. Solder Termination, 20 Position
P21	Connector, Ribbon, Female, Polarized, 20 Position
J33	Connector, Right Angle, 0.156 Ctrs, 3 Position
R1	Resistor, Fixed, Carbon Compound, 27 Ω, 1/4 W, ±5%
R2, R4, R6, R8, R10, R12, R14, R16, R18, R20, R22, R24	Resistor, Fixed, Carbon Compound, 150 Ω, 1/4 W, ±5%
R3, R5, R7, R9, R11, R13, R15, R17, R19, R21, R23, R25	Resistor, Fixed, Carbon Compound, 47 KΩ, 1/4 W, ±5%
C1...C12	Capacitor, Electrolytic, 1 µF, 50 WVdc
C13	Capacitor, Electrolytic, 10 µF, 25 WVdc
CR1...CR16	Diode Signal, Silicon
Q1...Q12	Transistor, Power Fet, VMOS, N-Channel, Enhancement Mode
S1, S2, S3, S4	Switch, P.C. Mounted, Toggle SPDT, PN 67183
S5	Switch, P.C. Mounted, Toggle SPDT, PN 68048
S6	Switch, P.C. Mounted, Toggle SPDT, PN 68047
S7	Switch, P.C. Mounted, Toggle SPDT, PN 68049
Z1	Resistor, SIP, 10K, 6-pin
Z2	Integrated Circuit, 4-Bit Latch/4 to 16 Line, Decoder



NOTES:
1. UNLESS OTHERWISE SPECIFIED:
a. ALL RESISTORS ARE IN OHMS, 1/4W, ±5%.
b. ALL CAPACITORS ARE IN MICROFARADS.

Figure 6-11. Schematic for LED Display Printed Circuit Board, PN 50680-1

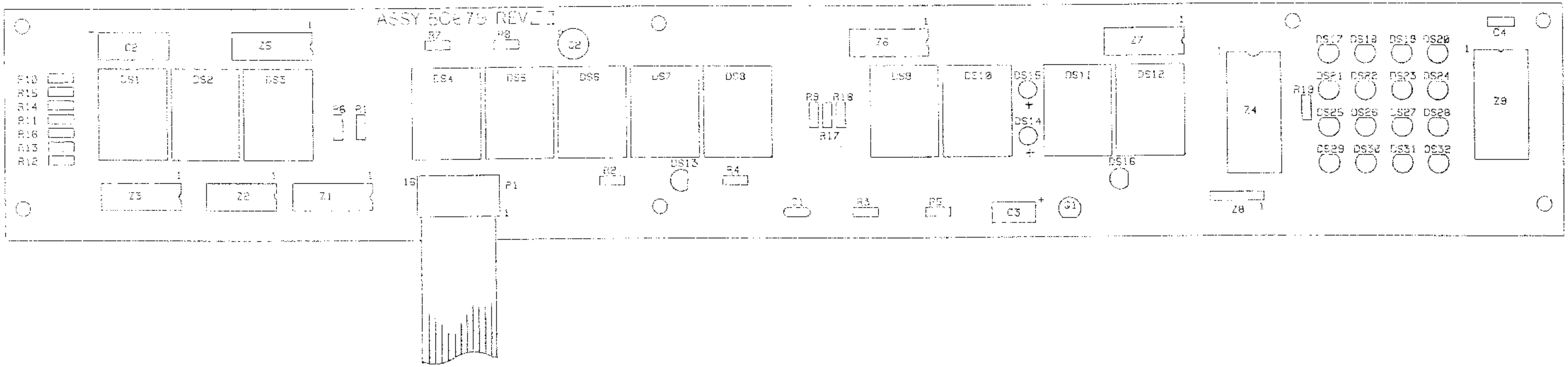


Figure 6-12. Component Location: LED Display Printed Circuit Board, PN 50679-3

Table 6-5. Component Description, LED Diaplay Printed Circuit Board, PN 50679-3

(refer to figure 6-12)

Component	Description
R1, R2, R6	Resistor, Fixed, Carbon Compound, 220 Ω, 1/4 W, ±5%
R3, R4	Resistor, Fixed, Carbon Compound, 4.7 KΩ, 1/4 W, ±5%
R5	Resistor, Fixed, Carbon Compound, 27 KΩ, 1/4 W, ±5%
R7	Resistor, Fixed, Carbon Compound, 1 KΩ, 1/4 W, ±5%
R8	Resistor, Fixed, Carbon Compound, 10 KΩ, 1/4 W, ±5%
R9, R17	Resistor, Fixed, Carbon Compound, 33 Ω, 1/4 W, ±5%
R10, R11, R12, R13, R14, R15, R16	Resistor, Fixed, Carbon Compound, 4.7 Ω, 1/4 W, ±5%
R18	Resistor, Fixed, Carbon Compound, 47 Ω, 1/4 W, ±5%
R19	Resistor, Fixed, Carbon Compound, 180 Ω, 1/4 W, ±5%
C1	Capacitor, Ceramic Molded, 0.1 µF, 100 WVdc
C2	Capacitor, Electrolytic, Aluminum, 100 µF, 25 WVdc
C3	Capacitor, Electrolytic, Aluminum, 1.0 µF, 63 WVdc
C4	Capacitor, Ceramic Molded, 0.01 µF, 100 WVdc
Q1	Transistor, NPN
Q2	Transistor, Power, Silicon, PNP
DS1, DS2, DS3, DS4, DS5, DS6, DS7, DS8, DS9, DS10, DS11, DS12	Diode, Light Emitting, 0.800 inch Common Cathode, RHDP
DS13, DS16	Lamp, Indicator, Green
DS14, DS15	Lamp, Indicator, Red
DS17, DS18, DS19, DS20, DS21, DS22, DS23, DS24, DS25, DS26, DS27, DS28, DS29, DS30, DS31, DS32	Lamp, Indicator, Yellow

Table 6-5. Component Description, LED Diaplay Printed Circuit Board, PN 50679-3
(refer to figure 6-12) continued

Component	Description
Z1	Integrated Circuit, BCD-to-Seven-Segment Decoders/Drivers
Z2	Resisitor, Network, 14-pin DIP, 100 Ω, 1.5 W
Z3	Integrated Circuit, General Purpose High Current Transistor Array
Z4	Integrated Circuit, 4 Line to 6 Line Decoder, 24-pin DIP
Z5, Z6, Z7	Integrated Circuit, Darlington Switch, 16-pin DIP
Z8	Resistor, Network, 6-pin SIP 10 K, 0.75 W
Z9	Integrated Circuit, 4 Line to 6 Line, 24-pin Decoder/Demultiplexes

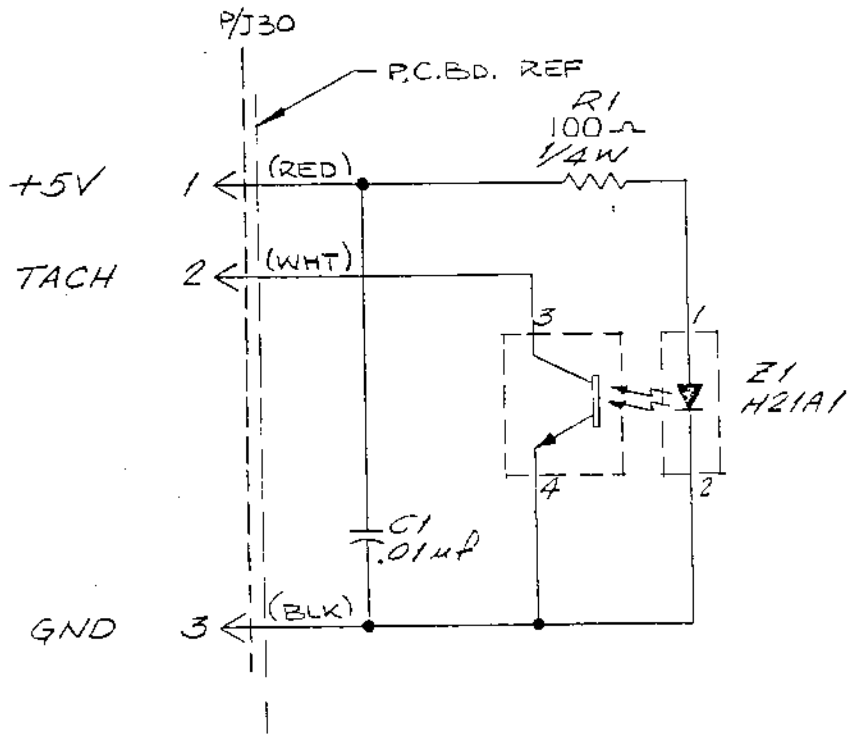
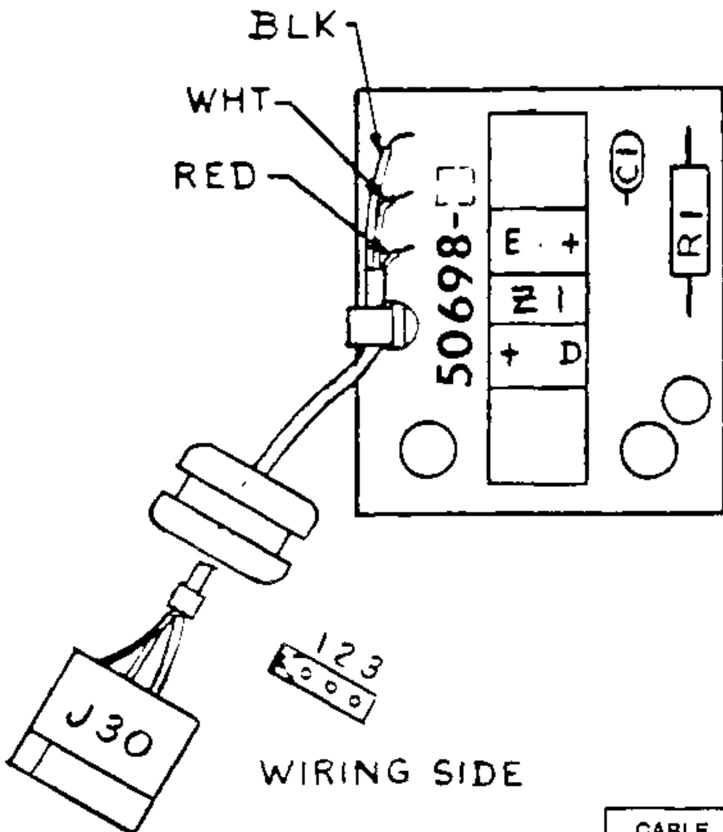


Figure 6-13. Schematic for Tachometer Printed Circuit Board, PN 50699-3



CABLE	FROM	TO	FUNCTION
RED	J30-1	RED	+5V
WHITE	J30-2	WHITE	TACH
BLACK	J30-3	BLACK	GROUND

Figure 6-14. Component Location: Tachometer Printed Circuit Board, PN ~~50698-3~~ 55635

Table 6-6. Component Description, Tachometer Printed Circuit Board, PN ~~50698-3~~ 55635

(refer to figure 6-14)

Component	Description
Z1	Integrated Circuit, PhotonCoupled, Interrupter Module
R1	Resistor, Carbon Compound, 100 Ω, 1/4 W, ±5%
C1	Capacitor, Ceramic Molded, 0.1 µF, 100 WVdc
J30	Connector Body, Plug, Elec, 3 Position

RC-5C *Plus*
Table of Contents

Section 13: *ILLUSTRATED PARTS*

This section provides illustrations of RC-5C PLUS assemblies and each illustration is keyed by item numbers to an accompanying parts list. The parts lists provide the part numbers and descriptions of each item that is called out on the illustrations. When ordering replacement parts, specify the part number and description, and the serial number of the centrifuge.

NOTE:

Tables throughout this section contain part numbers valid at the time of printing. All part numbers are subject to change without notice. Part numbers in **BOLD BLACK** type are currently stocked at our parts depot and are routinely available. Other parts listed in **RED** will be provided on a best effort basis.

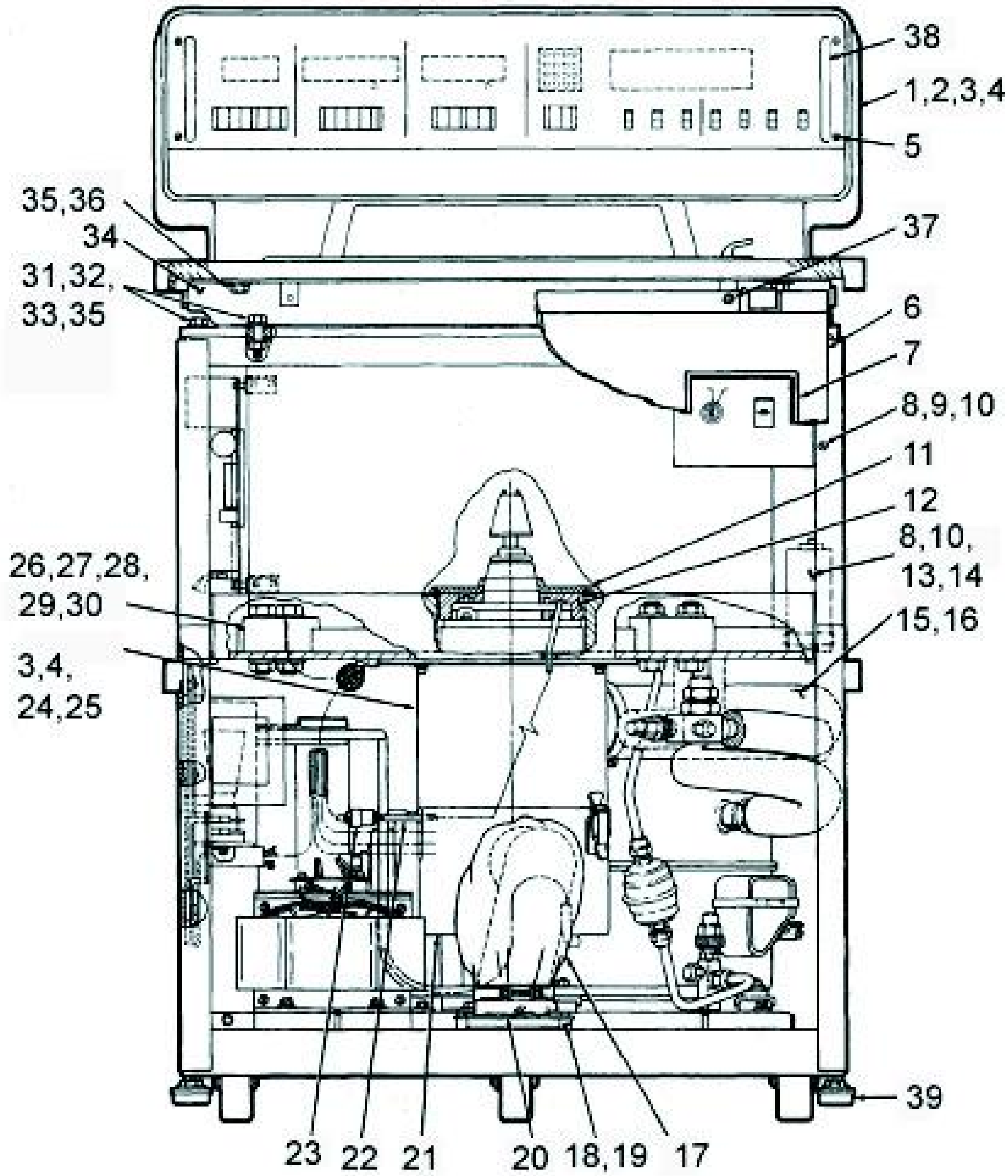


Figure 13-1. RC-5C Assembly, Front View

Item No.	Description	Part No.
1	CONSOLE ASSY, RC-5C	50611
2	BOLT, HEX HD, STL, CAD PLTD, 1/4-20 x 1 3/8 LG	63191
3	W ASHER, 1/4 FLAT, STL, CAD PLTD, 5 /8 O.D. x 9 /32 I.D. x 1 /16 THK	60233
4	WASHER, 1/4 SPLIT LOCK, STL, CAD PLTD	60448
5	SCREW, MACH, TRUSS HD, PHILLIPS, SST , UNC #8-32 x 5/16 LG	68044
6	PANEL ASSEMBLY	**50661**
7	BEZEL, PANEL, C IRCUIT BREAKER	52806
8	SCREW, M ACH, PAN HD, SLOTTED, SST, #8-32 x 3/8 LG	62358
9	W ASHER, #8 FLAT, SST, 3 /8 O.D. x 11/64 I.D. x .031 THK	60171
10	W ASHER, #8 SPLIT LOCK, SST	60172
11	SEAL, COVER, GYRO, RC-5B	**50414**
12	DISC, INSULATING FOAM	**50415**
13	CAPACITOR, MOTOR RUN, 20 MFD, 330 Vac	**66961**
14	BRACKET, CAPACITOR, UNIVERSAL WRAP AROUND	66957
15	HOSE ASSY, OUTLET	**50429**
16	CLAMP, HOSE, 3” DIA HOSE	**66632**
17	HOSE ASSY, INLET	**50428**
18	SPACER, ROUND, 1 /2 O.D. x .171 I.D. x 1 /2 LG	**64401**
19	SCREW, PAN HD, SST, #6-32 x 3 /4 LG	65766
20	INLET, HOSE ADAPT	50225
21	SILENCER, BOTTOM	**50190**
22	HARNESS, SUBASSY, IMBALANCE DETECTOR	**50778**
23	CONNECTOR BODY, PLUG, ELEC, 3 POSN	**67669**
24	SCREW, CAP, SOC HD, STL, 1/4-20 x 3/4 LG	60447
25	SILENCER, TOP	**50189**
26	HOLD DOWN BLOCK (GUARD TO BASE)	20839
27	BOLT, HEX HD, GRADE 5 STL, CAD PLTD, 5/8-11 x 1-1/2 LG	65646
28	W ASHER, FLAT, 5/8, STL, CAD PLTD, 1-1/4 O.D. x 41/64 I.D. x 1/16 THK	65647
29	W ASHER, 5 /8 SPLIT LK, ST L, CAD PLTD, MED SERIES	65648
30	NUT, HEX, JAM, GRADE 5 , STL, 5/8-11	64784
31	NUT, HEX, STL, CAD PLTD, 3/8-16	62681
32	W ASHER, FLAT 3/8 STL, CAD PLTD, 13/32 I.D. x 13/16 O .D. x 1/16 THK	61627
33	SCREW, CAP, HEX HD, STL, 3 /8-16 x 1-1/2 LG	66027
34	SUPPORT ASSY, TOP DECK, FRONT	50430
35	W ASHER, 3 /8 SPLIT LOCK, STL, MED, CAD PLTD	**61626**
36	SCREW, HEX HD, 3 /8-16 x 3 /4 LG , STL CAD PLATE	64743
38	BAR	50731
39	LEVELING PAD	**60619**
40	RC-5B/5C PREVENTATIVE MAINTENANCE KIT	**12010**

Table 13-1. RC-5C Assembly, Front View

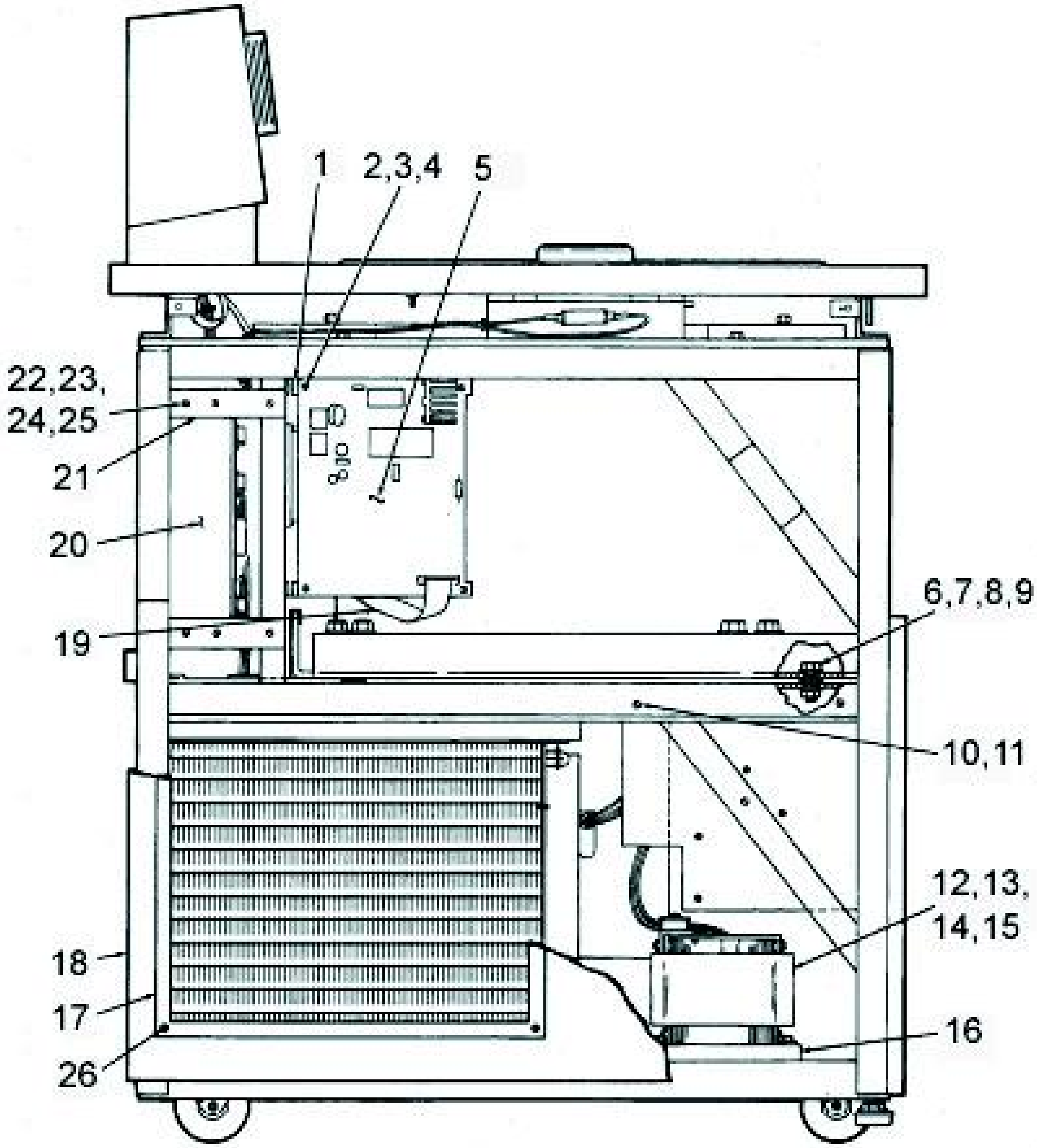


Figure 13-2. RC-5C Assembly, Left View

Item No.	Description	Part No.
1	BRACKET, SUBASSY, HIGH VOLTAGE INTERFACE	50768
2	SCREW , MACH, PAN HD, SLOTTED, STL, CAD PLTD #6-32 x 1/2 LG	60971
3	WASHER, #6 SPLIT LOCK, SST, MED	62021
4	WASHER, FLAT, #6, .169 I.D. x .304 O.D. x .032 THK, SST	63085
5	P.C. BOARD ASSY, HIGH VOLTAGE INTERFACE	**50710**
6	SCREW , CAP, HEX HD, STL, 3/8-16 x 1 LG	61665
7	WASHER, 3/8 SPLIT LOCK, STL, MED, CAD PLTD	61626
8	NUT, HEX, STL, CAD PLTD, 3/8-16	62681
9	WASHER, FLAT 3/8, STL, CAD PLTD, 13/32 I.D. x 13/16 O.D. x 1/16 THK	61627
10	SCREW, MACH, PAN HD, SST, #10-32 x 1/2 LG	61124
11	WASHER, #10 SPLIT LK, SST, LIGHT SERIES	60346
12	REACTOR ASSY, (220V/50 HZ)	**74075**
12	REACTOR ASSY, (208V/60 HZ)	**74075**
12	REACTOR ASSY, (240V/50 HZ)	**74075**
12	REACTOR ASSY, (230V/60 HZ)	**74075**
13	SCREW, CAP, SOC HD-HEX, STL CAD PLTD, UNC, 1/4-20 x 1-1/2 LG	64281
14	WASHER, #1/4, 9/32 I.D. x 5/8 O.D. x 1/16 THK, STL CAD PLTD	60233
15	WASHER, LOCK SPLIT, #1/4 x .045 THK, STL CAD PLTD	60448
16	SPACER	50397
17	BEZEL, CONDENSER	50434
18	PANEL ASSEMBLY	50375
19	CABLE ASSY, CONTROL, RC-5C	**50806**
20	POWER SUPPLY, SUBASSY, RC-5C	**74235**
21	BRACKET, SUBASSY, MOUNTING POWER SUPPLY	50754
22	NUT, HEX, SST, #6-32	60074
23	SCREW, MACH, PAN HD, SLOTTED, STL, CAD PLTD, #6-32 x 1/2 LG	60971
24	WASHER, #6, SPLIT LOCK, SST, MED	62021
25	WASHER, FLAT, #6, SST, .169 I.D. x .304 O.D. x .032 THK	63085
26	RIVET, POP, OPEN END, DOMED HD, AL, 5/32 DIA x .379 LG	66045

Table 13-2. RC-5C Assembly, Left View

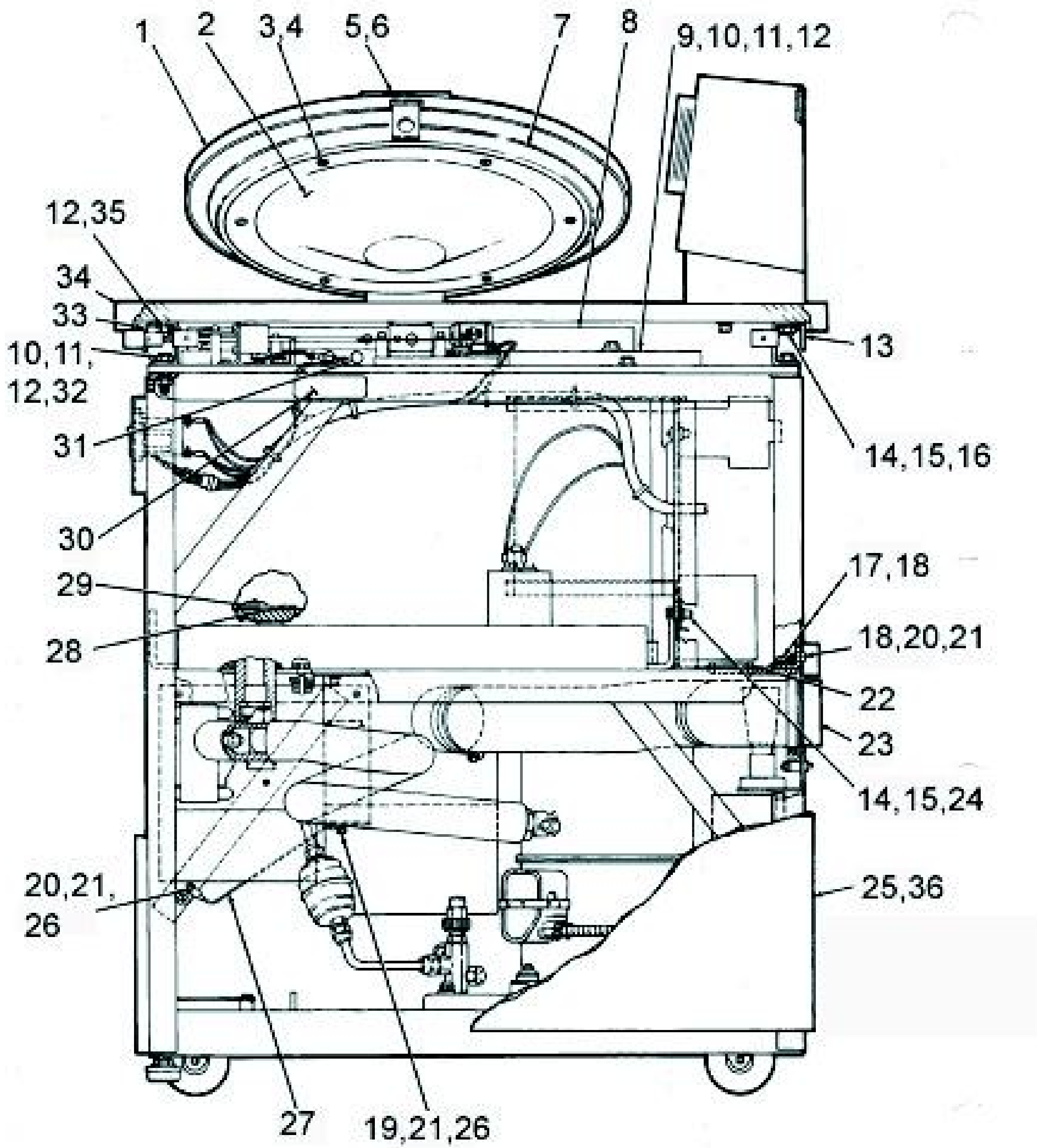


Figure 13-3. RC-5C Assembly, Right View

Item No.	Description	Part No.
1	DOOR ASSY	**50095**
2	DIFFUSER ASSY	**20785**
3	SCREW, WOOD, OVAL HD, PHIL, SST, #19 x 1-1/4 LG	**60683**
4	SCREW, WOOD, OVAL HD, PHIL, SST, #19 x 1-1/4 LG	**65676**
5	HANDLE, DOOR	**66306**
6	SCREW, CAP, FLAT HD, SOCKET HEX, STL BLK OXIDE, UNF #8-32 x 1 LG	**66982**
7	SEAL, UPPER, DOOR	**50473**
8	SHROUD	50094
9	PLATE, TOP, EVAPORATOR	**50610**
10	SCREW, CAP, HEX HD, STL, 3 /8-16 x 1-1/2 LG	66027
11	WASHER, FLAT 3 /8, STL, CAD PLTD, 13/32 I.D. x 13/16 O.D. x 1 /16 THK	61627
12	WASHER, 3/8 SPLIT LOCK, STL, MEO, CAP PLTD	61626
13	SUPPORT ASSY, TOP DECK (REAR) RC-5C	50616
14	WASHER, 1/4 FLAT, STL, CAD PLTD, 5 /8 O .D. x 9 /32 I.D. x 1/16 THK	60233
15	WASHER, 1/4 SPLIT LOCK, STL, CAD PLTD	60448
16	BOLT, HEX HD, STL, CAD PLTD, 1 /4-20 x 1-3/8 LG	63191
17	SCREW, MACHINE, PAN HD, SLOTTED, SST, #8-32 x 3/8 LG	62358
18	WASHER, FLAT, #10, SST	61652
19	NUT, HEX, SST, #10-32	60012
20	SCREW, MACHINE, PAN HO, SST, #10-32 x 1 /2 LG	61124
21	WASHER, #10 SPLIT LK, SST, L IGHT SERIES	60346
22	GROMMET, RUBBER	60363
23	OUTLET, HOSE ADAPTER	50393
24	SCREW, HEX, HD CAP, 1 /4-20 x 5 /8 LG, STL, CAD PLTD	61258
25	PANEL ASSY, S IDE, R IGHT	50378
26	WASHER, LOCK, INTERNAL TOOTH, #10	61712
27	STRAP ASSY, GROUNDING	20098
28	SENSOR ASSY, FLOOR TEMP	**74596**
29	SENSOR ASSY, AIR TEMP	**74579**
30	LABEL, HIGH VOLTAGE	**61223**
31	CORK, #4	66633
32	NUT, HEX, STL, CAD PLTD, 3 /8-16	62681
33	SUPPORT ASSY, TOP DECK, FRONT	50430
34	DECK ASSY	**50256**
35	SCREW, HEX HD, 3 /8-16 X 3 /4 LG, STL CD PLTD	64743
36	KSB PLUG, OUTER (NOT SHOWN)	**20972**
	Silencer, Top	**50189**
	Silencer Bottom	**50190**
	Hose Clamp, Silencer	**66632**
	Exhaust Hose	**50429**

Table 13-3. RC-5C Assembly, Right View

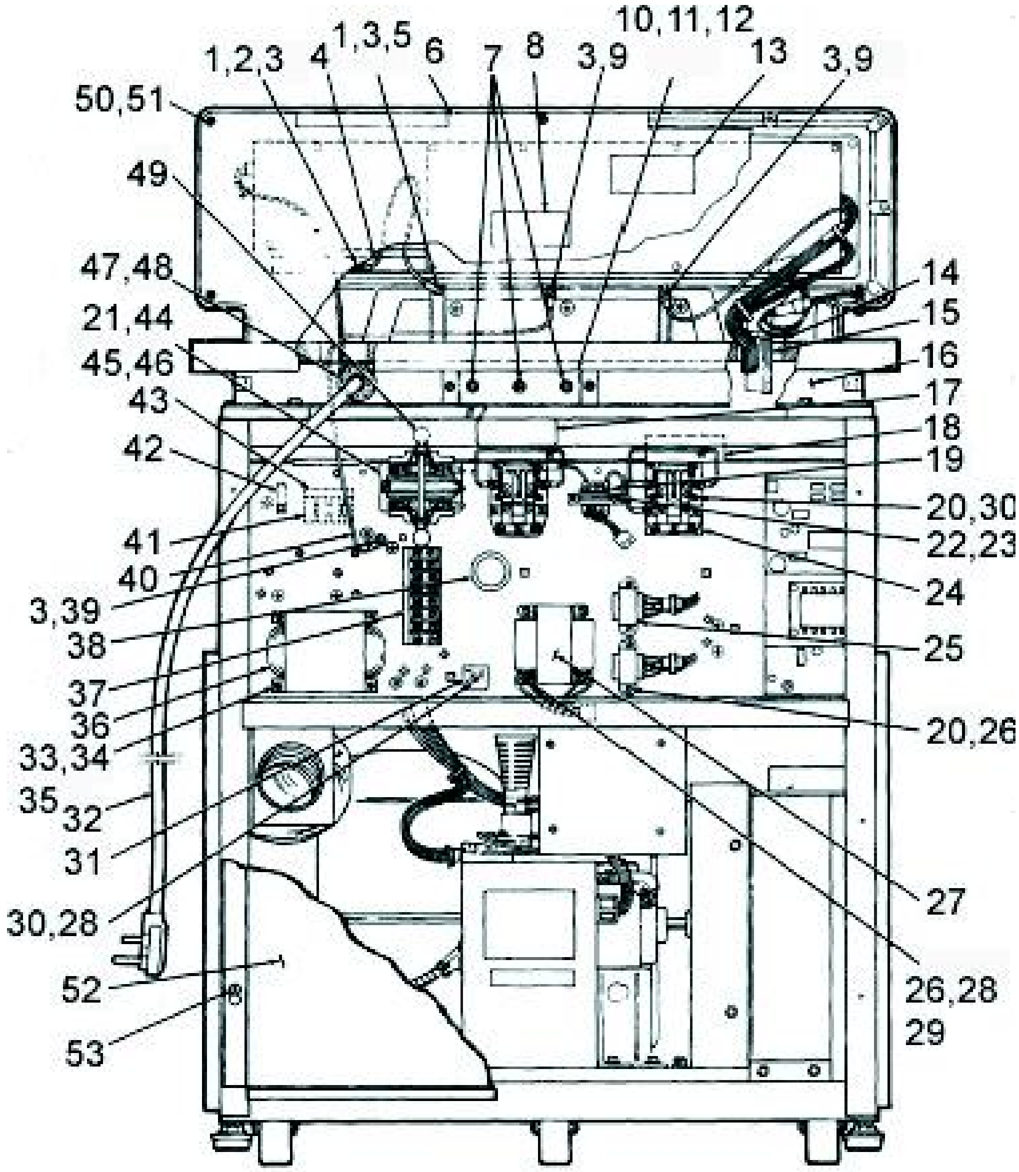


Figure 13-4. RC-5C Assembly, Rear View

Item No .	Description	Part No.
1	WASHER , LOCK, SPLIT, #10 SST .040 THK	63016
2	NUT , HEX, SST , UNF , # 10 -32	61757
3	WASHER , LOCK, EXTERNAL TOOTH , #10 SST	67896
4	STRAP ASSY, PANEL GROUNDING	50807
5	SCREW , MACHINE, PAN HD , SLOTTED , SST , UNF , # 10 -32 x 3/8 L G	61597
6	COVER, REAR, CONSOLE	50727
7	CIRCUIT BREAKER, 1 AMP, 250 V ac	**66760**
9	SCREW , MACHINE, PAN HD , S ST , #10 -32 x 1/2 LG	61124
10	SCREW , M ACHINE, PAN HD, SLOTTED, SST , #8-32 x 32 LG	62358
11	WASHER, #8 SPLIT LOCK, SST	60172
12	BRACKET, BREAKER	50624
13	LABEL , W ARNING	**61222**
14	CLAMP , CABLE , FLAT, ADHESIVE MOUNT	67294
15	CABLE ASSY, CONTROL	**50806**
16	SUPPORT ASSY, TOP DECK (REAR)	50616
17	LABEL, DANGER, HIGH VOLTAGE	**61223**
18	INSULATOR	50852
19	TRANSFORMER ASSY, CURRENT LIMITING	**50784**
20	WASHER, LOCK, SPLIT , #8 x .031 THK , SST	60172
21	WASHER, FLAT, SST, # 10 , 13/64 I.D. x 7/1 6 OD. x .031 THK	61984
22	SCREW, MACHINE, PAN HD, SLOTTED, STL CD PL	60971
23	WASHER, LOCK SPLIT, #6, SST , .031 THK	63011
24	RELAY, POWER, HEAVY DUTY, 24 Vdc	**66922**
25	TRANSFORMER SUBASSY, RELAY PANEL	**50799**
26	SCREW, MACHINE, PAN HD, SLOTTED, SST , UNC #8-32 x 1/4 LG	61437
27	TRANSFORMER, CURRENT LIMITING	**50779**
28	WASHER, #8 11/64 I.D. x 3/8 O.D. x .031 THK, SST	60171
29	SCREW, MACHINE, PAN HD, SLOTTED, SST, UNC # 8 -32 x 5/16 LG	61818
30	SCREW, MACHINE, PAN HD , SLOTTED , SST , UNC # 8 -32 x 9/16 LG	61984
31	RECTIFIER	**923627**
32	POWER CORD	**64065**
33	WASHER, LOCK, SPLIT, #10 x .040 THK , SST	60346
3 4	WASHER, FLAT, SST , #10-13/64 I.D . x .031 THK	61652
35	SCREW , MACH, SLOTTED, SST , UNF , #10-32 x 5/16 LG	60855
36	TRANSFORMER ASSY.	**20938**
37	TERMINAL BLOCK, BARRIER TYP E, 6 TERM, 30 AMP SPECIAL	**67969**

Table 13-4. RC-5C Assembly, Rear View

Item No.	Description	Part No.
38	GROMMET, NEOPRENE, 15/16 I.D. x 11/16 O.D. x 15/16 THK	68059
39	NUT, HEX, SST, #10-32	60012
40	STRAP ASSY, GROUNDING	50805
41	TERMINAL STRIP, 4 POLE, 40 AMP, 380/450V	**67415**
42	CONNECTOR. CABLE, #14-6 AWG RANGE, #10 MTG	65699
43	INSULATOR, TERMINAL BLOCK	50352
44	CONTACTOR, DEFINITE PURPOSE, 2 POLE, 24 Vdc	**66275**
45	SCREW, MACHINE, PAN HD, SLOTTED, SST, UNF #10-32 x 3/8 LG	61597
46	WASHER, LOCK, SPLIT, #10 SST, .047 THK	61652
47	STRAIN RELIEF	**68037**
48	NUT (STRAIN RELIEF)	**68038**
49	VARISTOR ASSY	**50615**
50	SCREW, PAN HD. SST, #10-24 x 7/16 LG	61837
51	WASHER, FLAT, #10, SST	61652
52	PANEL ASSY, REAR	**50692**
53	SCREW, SELF THREAD, TRUSS HD, PHIL, SEMS, EXT TOOTH, #12-24 x 3/8 LG	67110

Table 13-4. RC-5C Assembly, Rear View

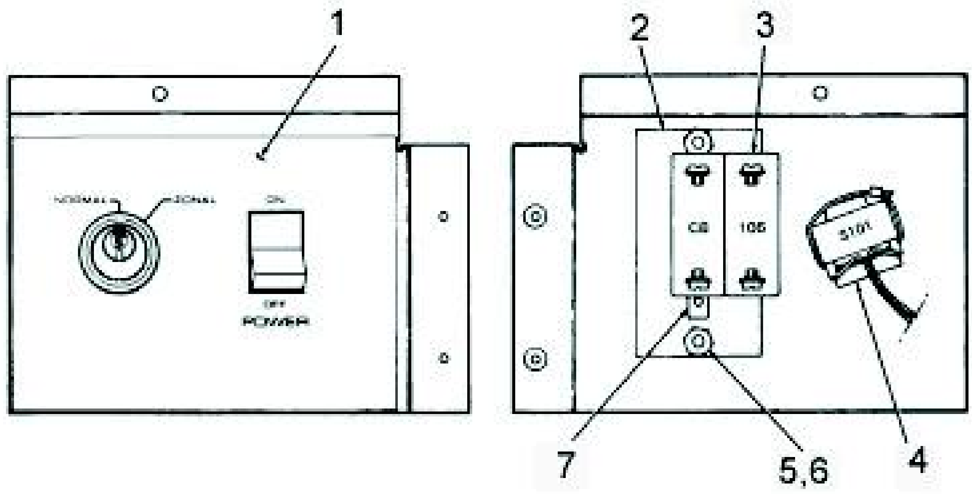


Figure 13-5. Panel Assembly, Keyswitch

Item No.	Description	Part No.
-	PANEL ASSY, KEYSWITCH	50751
1	OVERLAY, KEYSWITCH PANEL	50773
2	PLATE, MOUNTING, CIRCUIT PROTECTOR	**50097**
3	CIRCUIT PROTECTOR, TWO POLE, 30 AMP	**91476**
4	SWITCH ASSY, KEY, RC-5C	**50798**
5	NUT, HEX, SST, UNF, #10-32	61757
6	WASHER, LOCK, SPLIT, #10. SST, .040 THK	63016
7	SCREW, MACHINE, FLAT HD, SLOTTED, SST, UNC, #6-32 x 1/4 LG	60674
-	KEY	**65919**

Table 13-5. Panel Assembly, Keyswitch

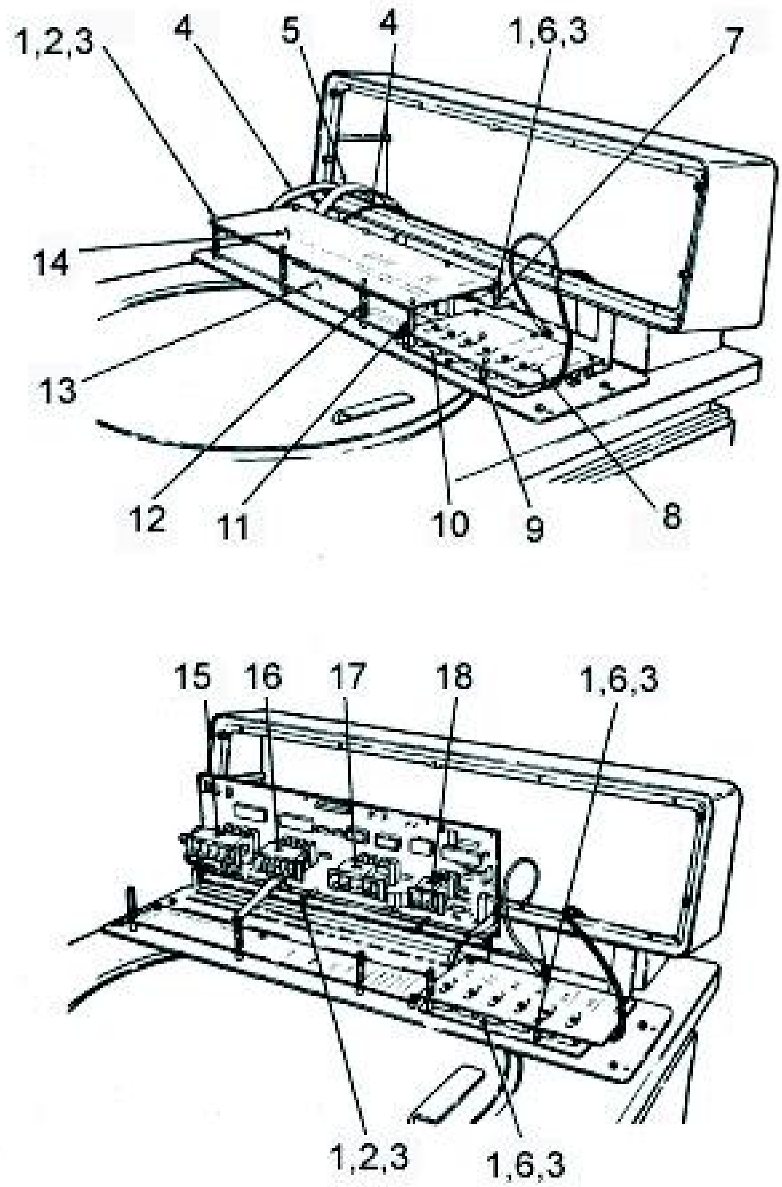


Figure 13-6. Front Console Panel Assembly

Item No.	Description	Part No.
1	SCREW , MACH, PAN HEAD, SLOTTED , SST , UNC #6-32 x 3/8 LG	61132
2	WASHER, FLAT, .169 I.D. x .304 O.D. x .032 THK. SST	63085
3	WASHER, LOCK, SPLIT , #6, SST, .031 THK	63011
4	HARNESS ASSY. MAIN	50809
5	CABLE ASSY, CONTROL	**50806**
6	NUT, HEX, SST, # 6 -32	60074
7	STANDOFF, MALE-FEMALE, 1/4 HEX x 1 " LG , #6-32, SST	67335
8	SWITCHES AND INDICATORS, PRINTED CIRCUIT BOARD ASSY	**50685**
9	STANDOFF, MALE-FEMALE, 1/4 HEX x 1 " LG , #6-32, SST	50756
10	REFLECTOR, L IGHT	**50645**
11	STANDOFF, FEMALE, 1/4 HEX x 1/4 LG, #6-32, SST	68046
12	STANDOFF, MALE-FEMALE, 1/4 HEX x 1-5 /8 LG, # 6-32 , SST	67337
13	LED DISPLAY, PRINTED CIRCUIT BOARD ASSY	**50679**
14	MICROCOMPUTER, PRINTED CIRCUIT BOARD ASSY	**56266**
15	SWITCH, MINILEVER, PANEL MOUNT, 5 STATION	**92253**
16	SWITCH, MINILEVER, PANEL MOUNT, 5 STATION	**92251**
17	SWITCH, MINILEVER, PANEL MOUNT, 5 STATION	**92250**
18	SWITCH, MINILEVER, PANEL MOUNT, 2 STATION	**92252**
---	SH-MT SOFTWARE UPGRADE KIT	**12814**
---	ROTOR LABEL I.D. STICKER (ONLY)	**50884**

Table 13-6. Front Console Panel Assembly

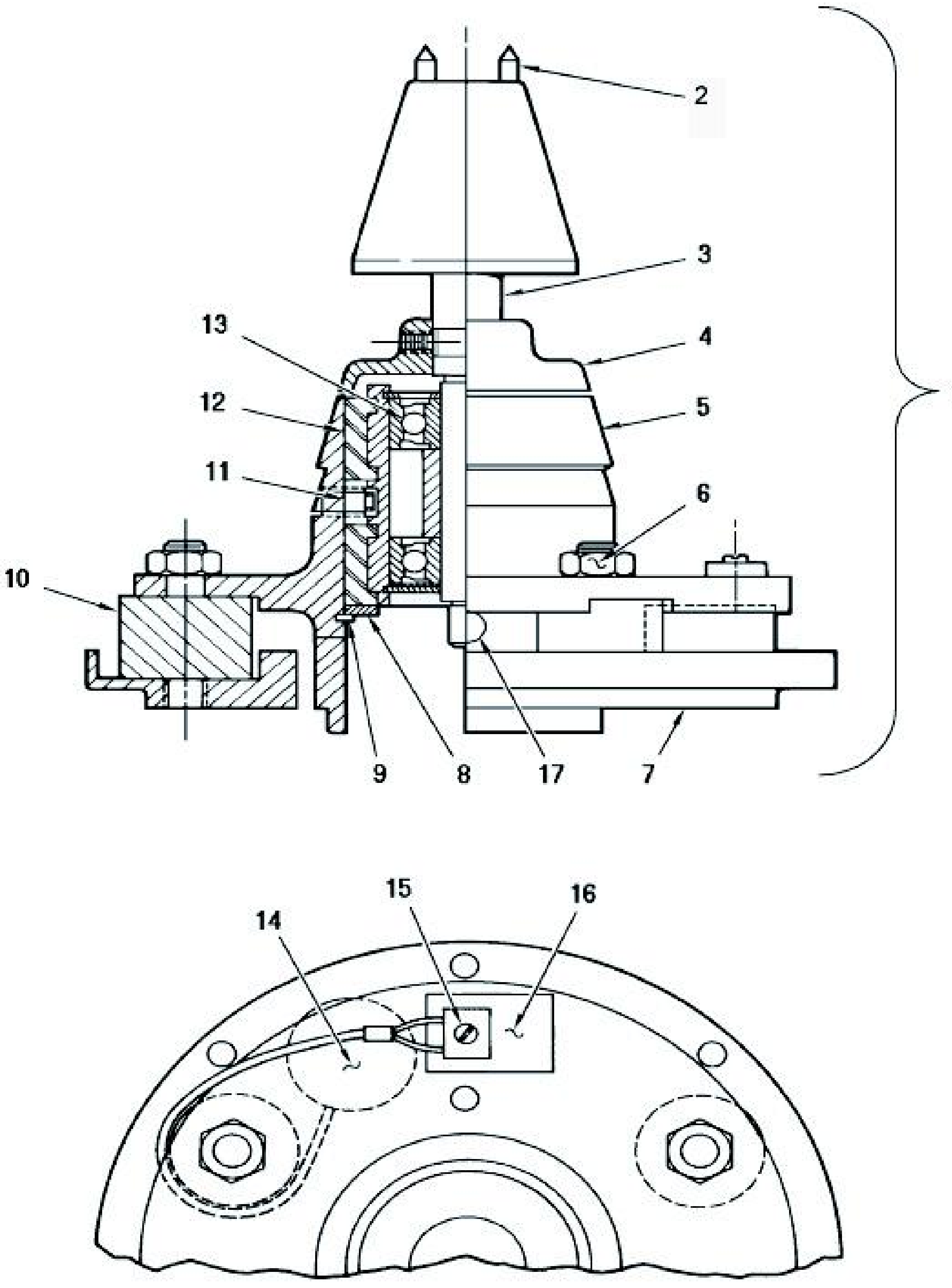


Figure 13-7. RC5C Drive Assembly

Item No.	Description	Part No.
1	RC-5C GYRO ACTION DRIVE ASSY (NEW)	**12817**
2	PIN, TAPERED SPINDLE	**204742**
3	SPINDLE ASSY	**12818**
4	SLINGER, SEALING	**12818**
5	PLATE, MOUNTING, UPPER	50812
6	NUT, HEX, SST, UNC 5/16-18	67273
7	PLATE, MOUNTING, LOWER	50407
8	WASHER, SUPPORT	50409
9	RETAINING RING	**67270**
10	MOUNT, FLEX-BOLT	**50408**
11	SCREW, SET, HEX SOCKET, SST, UNC 1/4-20 x 3/8 LG	**67272**
12	HOUSING ASSY, BEARING	**50579**
13	KIT, BEARING, REPLACEMENT	**12342**
14	DETECTOR, IMBALANCE	**50843**
15	SCREW , MACH, PAN HD , SLOTTED , SST, UNC, #2-56 x 1/4 LG	**63818**
16	INSULATOR	67710
17	PLUG, ACCESS HOLE	**67341**

Table 13-7. RC5C Drive Assembly

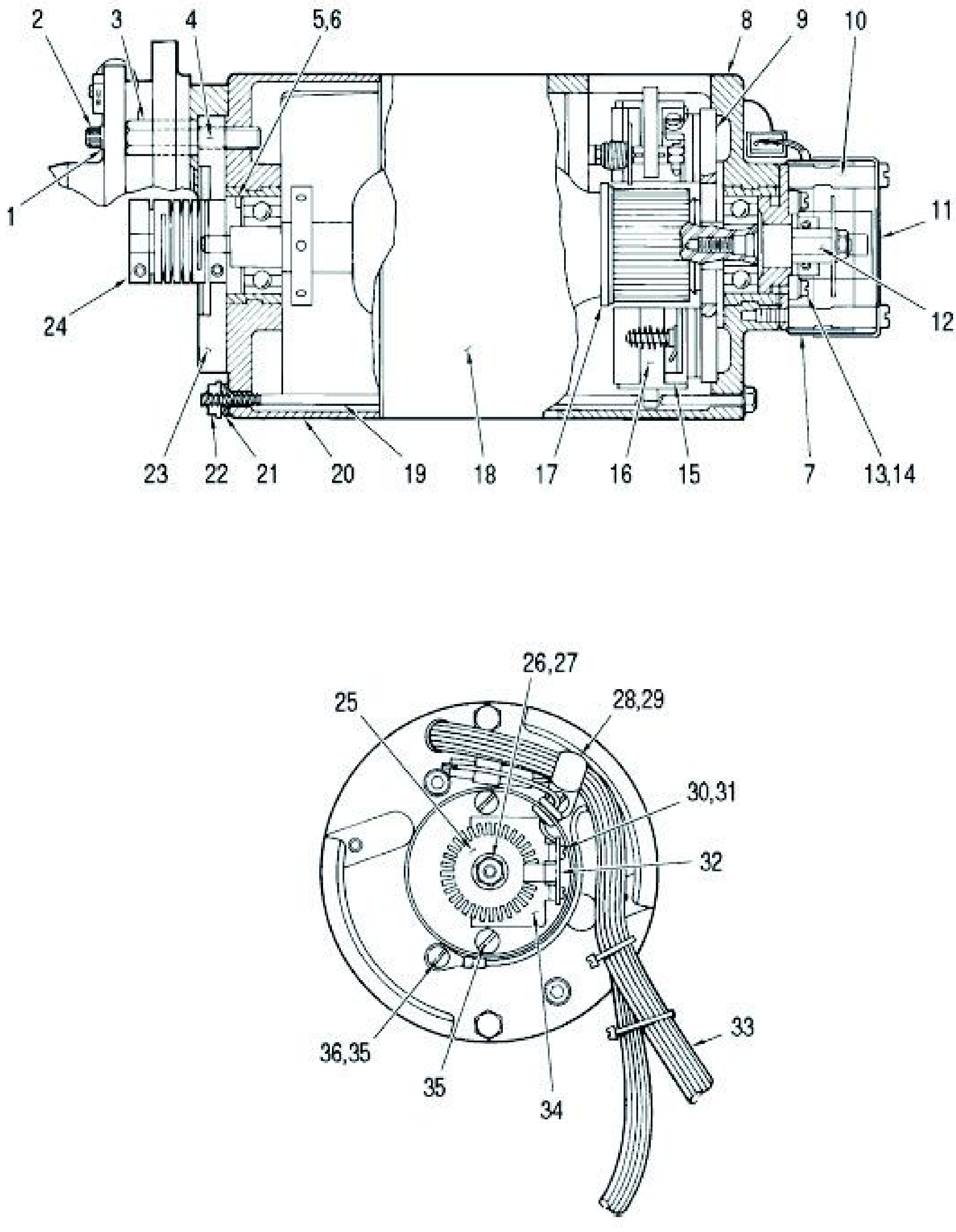


Figure 13-8. RC5C Low Noise Motor Assembly

Item N o.	Description	Part No.
---	RC-5C LOW NOISE MOTOR ASSY	**12991**
1	WASHER, LOCK, SPLIT, #10, SST, .040 THK	63016
2	SCREW, CAP, SOCKET HD HEX, SST, UNF, #10-32 x 3 /4 LG	60568
3	STANDOFF, 7/16 HEX, MALE 1/2-20 FEMALE #10-32	**50418**
4	ADHESIVE, SEALANT, LOCTITE, #222	**65811**
5	WASHER, SPRING, WAVY, 1.051 I.D. x 1.351 O .D.	67281
6	SHIM, .010 THK	**20483**
6	SHIM, .020 THK	**20509**
6	SHIM, .040 THK	**20510**
7	PLATE, BAFFLE, MOTOR	20471
8	BELL, END, LOWER, MOTOR	20445
9	DISC, INSULATING, MOTOR	**20478**
10	STANDOFF, DUST COVER, 5/16 D IA, MALE/FEMALE, #10-24 x 1 -1/4 LG	**50849**
11	COVER , DUST, OPTICAL PICK-UP	**50850**
12	SHAFT, OPTICAL P ICK-UP	**50617**
13	SCREW, MACHINE, PAN HD,SLOTTED, SST, #5-40 x 1/4 LG	**61498**
16	Brush, Commutator, 3/8" THK	**74196**
15	HOLDER ASSY, PLATE & BRUSH, RC-5C	50147
16	BRUSH, COMMUTATOR, ¼ " THK	**12284**
17	ARMATURE, ASSY, RC-5C (LOW NOISE)	12750
18	HOUSING & STATOR ASSY, MOTOR (MACHINING)	**20612**
19	ROD, TIE, MOTOR	20507
20	BELL, END, UPPER, MOTOR, RC-5C (LOW NOISE)	50421
21	WASHER, SPRING, BELLEVILLE, SPRING STEEL, .19 I.D. x .375 O .D. x .03 H x .02 THK	**61980**
22	NUT, FLANGE, LOW CARBON STL, CAD PL, UNC #10-29	**61815**
23	PLATE, PRELOAD	50416
24	COUPLING ASSY, RC-5B (LOW NOISE)	**12345**
25	DISC, OPTICAL PICK-UP	**50735**
26	NUT, HEX, SST , UNF, #10-32	**61757**
27	WASHER, LOCK, SPLIT, #10 SST, .040 THK	**63016**
28	CLAMP, CABLE, PLASTIC, 3/8 DIA, .204 MTG HOLE	**64111**
29	SCREW , MACHINE, PAN HD, SLOTTED, SST, UNC, #8-32 x 3/8 LG	62358
30	SCREW, MACH, PAN HD, SLOTTED, SST , UNC, #4-40 x 3/16 LG	62913
31	WASHER, LOCK, SPLIT, #4, SST, .031 THK	63006
32	PRINTED CIRCUIT BOARD ASSY, TACK PICK-UP	**55635**
33	HARNESS ASSY, MOTOR, RC-5C	**50814**
34	BRACKET	**50618**
35	SCREW , MACHINE, PAN HD, SLOTTED, SST, UNC, #10-24 x 1/4 LG	**61817**
36	WASHER, LOCK, #10 EXTERNAL TOOTH, SST	**67896**
---	MOTOR MOUNTING PLATE SPACER	**50486**

Table 13-8. RC5C Low Noise Motor Assembly

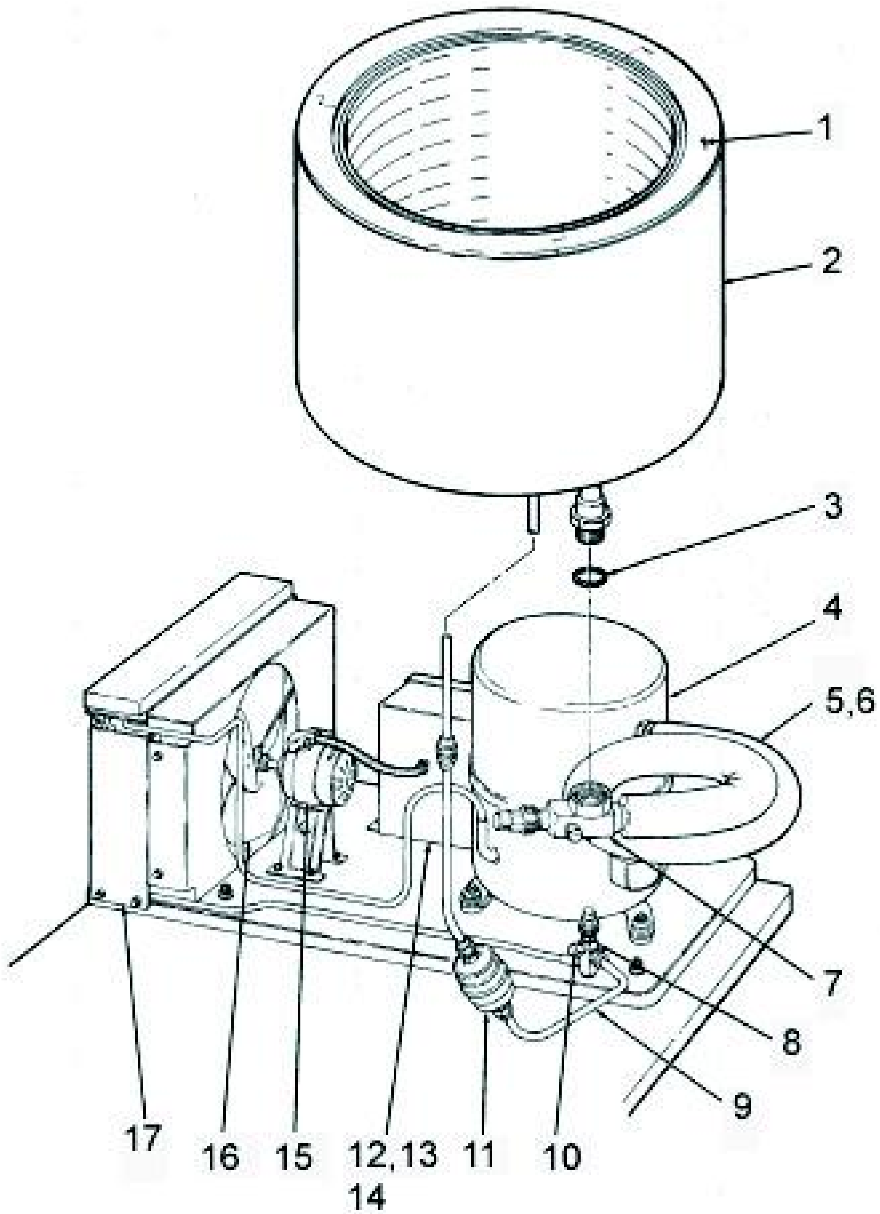


Figure 13-9. RC5C Condensing Unit Assembly and Evaporator Subassembly

Item #	Model Starting Serial # Ending Serial # Refrigerant	RC-5C Unknown 9300321 R502 Original Config.	RC-5C If upgraded prior to 7/99 HP-62 Replacement Parts	RC-5C If upgraded After 7/99 HP-62 AV series comp.
11	Filter Drier	**91470**	**91470**	**91470**
6	Suction Tube	**50350**	**50350**	**50362**
15	Condenser Fan Motor	**91392**	**91392**	**91392**
12	Run Capacitor	**67941**	**91983**	**92733**
13	Start Capacitor	**91981**	**91981**	**92734**
14	Potential Relay	**67943**	**91986**	**92732**
16	Condenser Fan Blade	**67944**	**91897**	**91897**
17	Condensing Assembly (Includes compressor, condenser, & associated tubing)	**20802***	**20802***	**20802***
	Teflon Seal (small)	**--------**	**66952**	**66952**
3	Teflon Seal (large)	**61768**	**61768**	**61768**
4	Compressor (use condensing assy. kit)	**20802***	**20802***	**20802***
2	Evaporator	**12236**	**12236**	**12236**
9	Tube, Filter to Service Valve (flare to flare)	**20654**	**--------**	**--------**
9	Tube, Filter to Service Valve (flare to Rotalock)	**--------**	**22011**	**22011**
1	Evaporator Insulation	**20094**	**20094**	**20094**

* New compressors are to be charged with Suva HP-62 or equivilent refrigeratant

Figure 13-9. RC5C Condensing Unit Assembly and Evaporator Subassembly

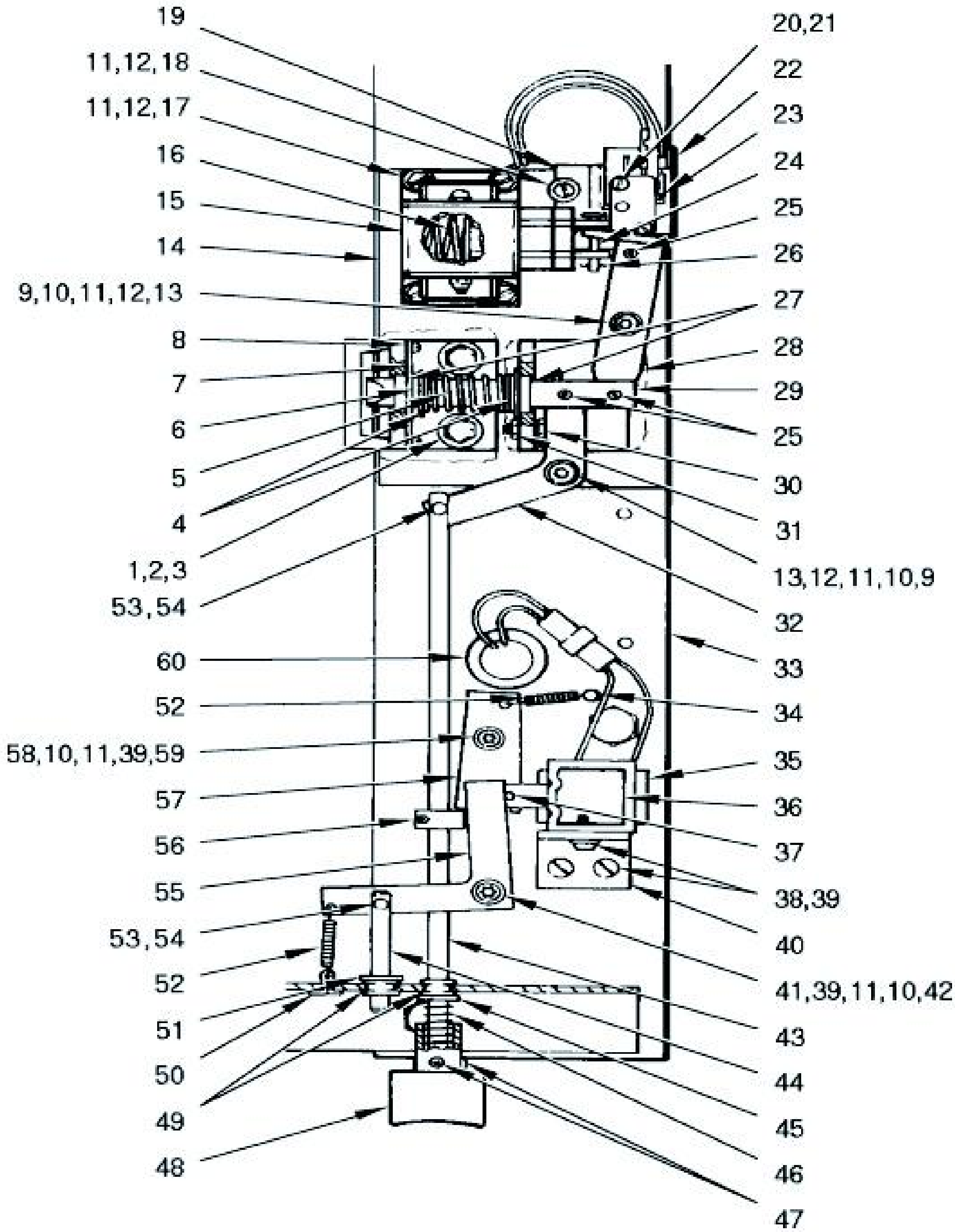


Figure 13-10. Door Interlock Assembly (Part A)

Item No.	Description	Part No.
1	WASHER, FLAT, 5/16, 11/32 I.D . x 1 1/16 O.D. x 1/16 THK, STL	60885
2	WASHER, 5/16 SPLITLOCK, SST, . 078 THK	63023
3	SCREW, MACH, HEX HD, STL, CAD PL, 5/16 -18 x 1 1/4 L6	64747
4	WASHER, FLAT, .515 I.D. x .875 O.D. x .016 THK, SST	66341
5	SPRING. COMPRESSION, .53 I.D. x 2.3 LG, .038 WIRE DIA	**50076**
6	RING, RETAINING, EXTERNAL, 1/2 “	**62503**
7	RETAINER, BUSHING	50111
8	SCREW, MACH, PAN HD, SST, UNC, 4 -40 x 3/16 LG	66343
9	SPACER, ROUND, 1/2 O.D. x 3/4 LG, ALUM	66391
10	BEARING, BRASS, .196 I.D. x .375 O.D. x .125 THK	50112
11	WASHER, FLAT # 10, SST	61652
12	WASHER, LOCK, # 10	60346
13	SCREW, CAP, HEX. SOCKET HD, SST, UNF, 10-32 x 1-1/4 LG	66342
14	WELDMENT ASSY, DOOR INTERLOCK	50077
15	SOLENOID, RC-5C, PULL TYPE, MODIFIED	50872
16	SPRING, COMPRESSION	68745
17	SCREW, MACH, HEX HD, SLOTTED, SST, UNF, 10-32 x 1/2 LG	66339
18	SCREW, MACH, PAN HD, SLOTTED, SST, UNF, #10-32 x 1/2 LG	61124
19	ASSY, BRACKET, MICROSWITCH, RC-5C	50887
20	SCREW, MACH, PAN HD, SLOTTED, SST, UNC, #4-40 x 5/8 LG	62396
21	WASHER, FLAT, #4, 1/8 I.D. x 1/4 O.D. x .022 THK, SST	61072
22	INSULATOR, FISH PAPER, 1-19/32 x 1 x .015 THK	**62245**
23	MICROSWITCH, MODIFIED	**66753**
24	PIN, CLEVIS, .187 DIA x .75 LG	**68080**
25	PIN, SPRING, SPIRAL, (1/8 x 9/16)	63238
26	PIN, HITCH, .042 DIA x 31/32 LG	**67567**
27	BEARING. NYLINER, FLANGED	**66314**
28	LINK, SOLENOID, RC-5C	**50870**
29	PLUNGER, DOOR INTERLOCK, RC-5C	**50871**
30	SCREW, MACH, HEX HD, SST, UNC, 6-32 x 5/8 LG	68746
31	NUT, HEX, TOPLOCK, #6-32, SST	61042
32	LINK, MANUALRELEASE, RC-5C	50869
33	PLATE, SUPPORT, DOOR INTERLOC K	50776
34	POST, SPRING, .188 DIA x 1.50 LG	68161
35	TAPE, INSULATING, 1“ x 1-1/2	67710
36	SOLENOID ASSY, RC-5C	**50803**
37	PIN, SPRING, SELFLOCKING, .093 DIA x .62	67904
38	SCREW, BINDING HD, SST, #10-32 x 5/16 LG	60855
39	WASHER, #10 SPLIT LK, SST, LIGHT SERIES	60346
40	BRACKET, SOLENOID	50501

Table 13-10. Door Interlock Assembly (Part A)

Item No.	Description	Part No.
41	SCREW , SOC HD CAP, #10-32 x 1-7/8 LG, SST	67906
42	SPACER, ROUND, .194 I.D. x 1/2 O.D. x 1-7/16 LG	68160
43	ROD, DOOR, MANUAL RELEASE	50881
44	ROD, SOLENOID RELEASE	50522
45	WASHER, 1/4 FLAT, STL, CAD PLTD, 5/8 O.D. x 9/32 I.D. x 1/16 THK	60233
46	SPRING, COMPRESSION, .360 O.D. x 1.00 FL x .032 WIRE	**67899**
47	SET SCR, SOC HD, CUP PT, #10-32 x 3/16 LG , STL	**64342**
48	BUTTON, DOOR INTERLOCK (MOLDED ASSY)	**50689**
49	BEARING, NYLON, SNAP-IN, SHAFT SIZE .250 DIA	**63985**
50	PIN , COTTER, SST, 1/16 DIA x 1/2 LG	60315
51	RING, RETAINING, EXT, 1/4 DIA SHAFT	**67903**
52	SPRING, EXT, .18 O.D. x 1.00 LG x .018 WIRE	**68209**
53	PIN, COTTER, HAIRPIN, SST, 19/32 LG	67959
54	RIVET, MODIFIED, INTERLOCK	50732
55	ARM, SOLENOID RELEASE	**50612**
56	COLLAR, CLAMP TITE	68172
57	LINK, INTERLOCK	50502
58	SPACER, ROUND, 1/2 O.D. x .194 I.D. x 1-1/8 LG	67900
59	SCREW, SOC HD CAP, #10-32 x 1-11/16 LG , SST	60580
60	BUSHING, SNAP, 3/4 I.D., 1.00 MTG HOLE	68214
---	DOOR INTERLOCK ASSEMBLY (ITEMS 1-32)	**50868**

Table 13-10. Door Interlock Assembly (Part A Continued)

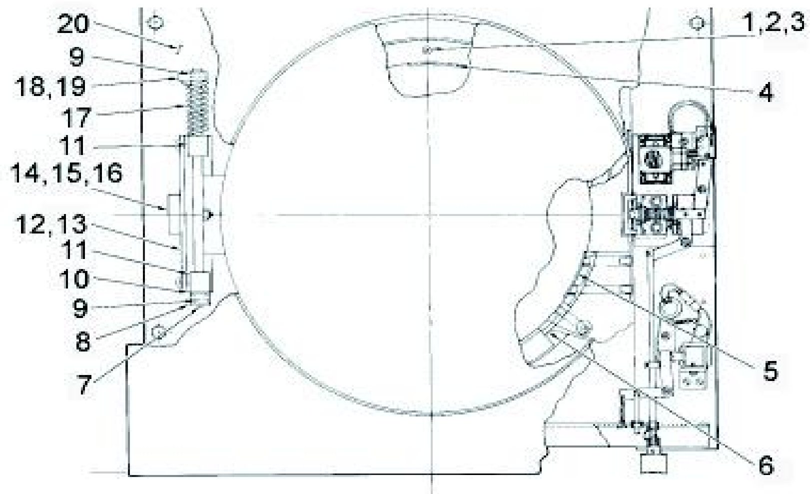


Figure 13-11. Door Interlock Assembly (Part B)

Item No.	Description	Part No.
1	SCREW, FLAT HD, PHILLIPS, WOOD #10 x 1-3/4 LG	**65660**
2	SEAL RING, DOOR, LOWER	**50079**
3	SHROUD	50094
4	LABEL, ROTATION	**62541**
5	STOPPER, KSB OUTLET	20845
6	LOWER SEALRING	**20006**
7	PIN, SPRING, SPIRAL 1/4 DIA x 1 LG	**63240**
8	STOP, DOOR	**50101**
9	PIN. SPRING, SPIRAL 3/16 DIA x 1 LG	**63239**
10	WASHER, FLAT, NYLON, 1/2 I.D. x 1 O.D. x 1/1 6 THK	66349
11	BLOCK. MOUNTING, SHAFT (SPRING)	**50102**
12	BRACKET, MOUNTING	**50083**
13	SHIM, HINGE	50274
14	SWITCH, PUSH BUTTON, SPDT	**66383**
15	NUT, THIN HEX, BRASS, 3/8-32 UNEF	66668
16	WASHER, INT TOOTH, SST, 3/8, .388 I.D. x .687 O.D.	62033
17	SPRING, TORSION, .55 I.D. x 2.8 LG	**50106**
18	SCREW, SET, SLOTTED, CUP POINT, 1/4-20 x 7/8	**66743**
19	RETAINER SPRING	**50100**
20	PLATE, SUPPORT, HINGE	**50080**

Table 13-11. Door Interlock Assembly (Part B)

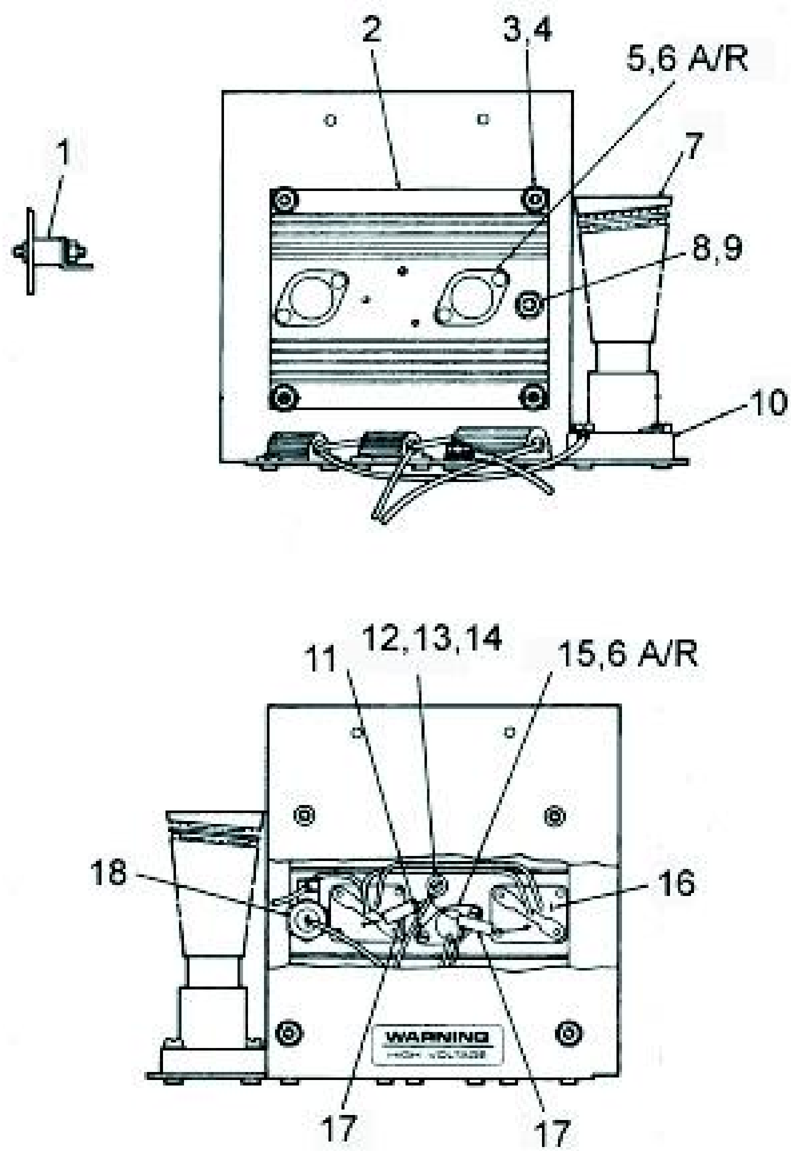


Figure 13-12. Constant Current Brake Assembly

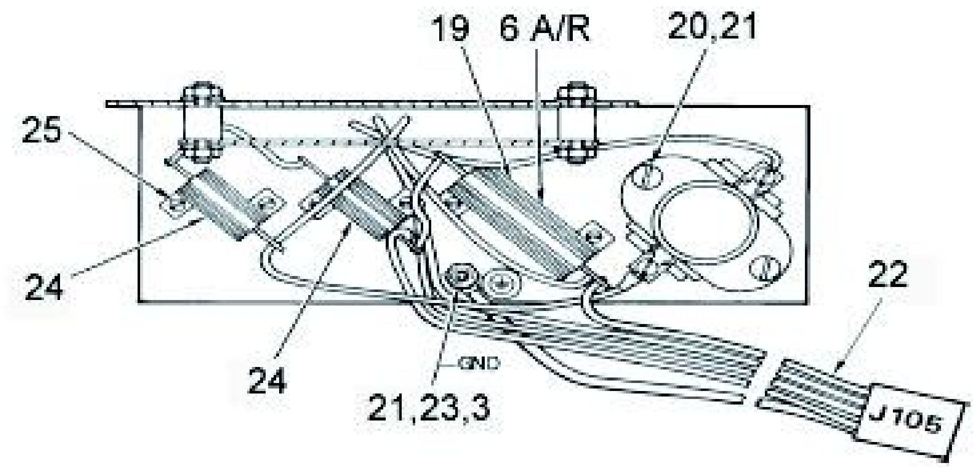


Figure 13-12. Constant Current Brake Assembly (Continued)

Item No.	Description	Part No.
---	CONSTANT CURRENT BRAKE ASSEMBLY	**50687**
1	STANDOFF, MALE, #10-32, DELRIN, NORELCOM #51130-R-D-.500 WITH .375 LG THRD	**68158**
2	HEATSINK, MOD RC-5C	50770
3	NUT. HEX, SST #10-32	60012
4	WASHER, FLAT, SST, #10, 13/64 I.D. x 7/16 O.D. x .031 THK	61652
5	TRANSISTOR, POWER NPN, 2N3055	**920505**
6	COMPOUND. THERMAL, 8 OZ JAR, WAKEFIELD #120-8	**NA**
7	RESISTOR. BRAKING, 2.7 OHMS, 1000 W	**61487**
8	NUT, HEX, SST. #1/4-20	61141
9	WASHER, LOCK, SPLIT, #1/4. SST, .047 THK	63019
10	RECEPTACLE, BRAKING, RESISTOR, 660 W, 250 V	**60406**
11	SCREW, MACHINE, PAN HD, SLOTTED. UNC #4-40 x 3/8 LG	62395
12	SCREW, NYLON, PAN HD, #6-32 x 1/2 LG	67606
13	WASHER, FLAT, NYLON. #10 x 1/8 THK	67383
14	WASHER, FLAT, .169 I.D. x .304 O.D. x .032 THK, SST	63085
15	THERMOSTAT	**68173**
16	MOUNTING KIT	65580
17	RESISTOR, WIREWOUND, .010 OHMS, 2 W	68171
18	RECTIFIER, SILICON, 100 V, 1N249C	**68563**
19	RESISTOR, WIREWOUND, 0.5 OHMS, 30 W	68170
20	SCREW, MACHINE, PAN HD, SLOTTED, SST, UNF #10-32 x 3/4 LG	61118
21	WASHER, LOCK, SPLIT, #10 SST, .040 THK	63016
22	HARNESS ASSY, BRAKE, CONSTANT CURRENT	50774
23	WASHER, LOCK. EXTERNAL TOOTH, #10, SST	67896
24	RESISTOR. WIREWOUND. 0.5 OHMS, 25 W	68169
25	SCREW, MACHINE, PAN HD, SLOTTED, SST, UNC #4-40 x 3/16 LG	62913
---	CONSTANT CURRENT BRAKE INSTALLATION KIT	**12795**

Table 13-12. Constant Current Brake Assembly

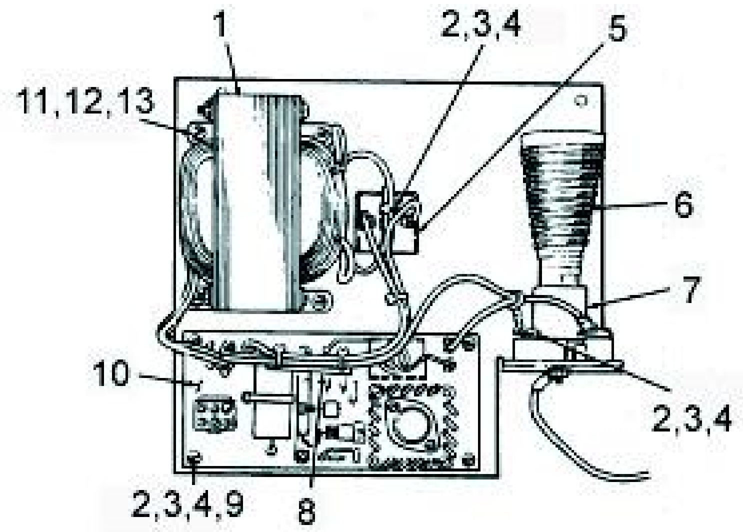


Figure 13-13. Slow Start Assembly

Item No.	Description	Part No.
---	SLOW START ASSY	50757
1	TRANSFORMER ASSY, RECTIFIER, POWER, SLOW START, RC-5C	50633
2	WASHER, LOCK, SPLIT, #8 SST .040 THK	63014
3	WASHER, FLAT, .169 I.D. x .304 O.D. x .032 THK SST	63085
4	SCREW, MACH, PAN HD, SLOTTED, SST, UNC, #8-32 x 3/4 LG	60927
5	RECTIFIER, BRIDGE, 30 AMP, MOTOROLA #MDA 990-4	**68115**
6	RESISTOR, BRAKING, 2.7 OHMS, 1000 W	**61487**
7	RECEPTACLE, BRAKING RESISTOR, 660 W, 250 V	**60406**
8	HARNESS ASSY, SLOW START, RC-5C	50802
9	SPACER, ROUND, 3/9 O.D. x 1/2 LG, NYLON, AMATON #9321-N194	65651
10	PRINTED CIRCUIT BOARD ASSY, SLOW START	**50716**
11	WASHER, LOCK, SPLIT, #10 SST. .040 THK	63016
12	WASHER, FLAT, #10 SST, 13/64 I.D. x 7/16 O.D. x .031 THK	61652
13	SCREW, MACH, PAN HD, SLOTTED, SST, UNF #10-32 x 3/8 LG	61597

Table 13-13. Slow Start Assembly

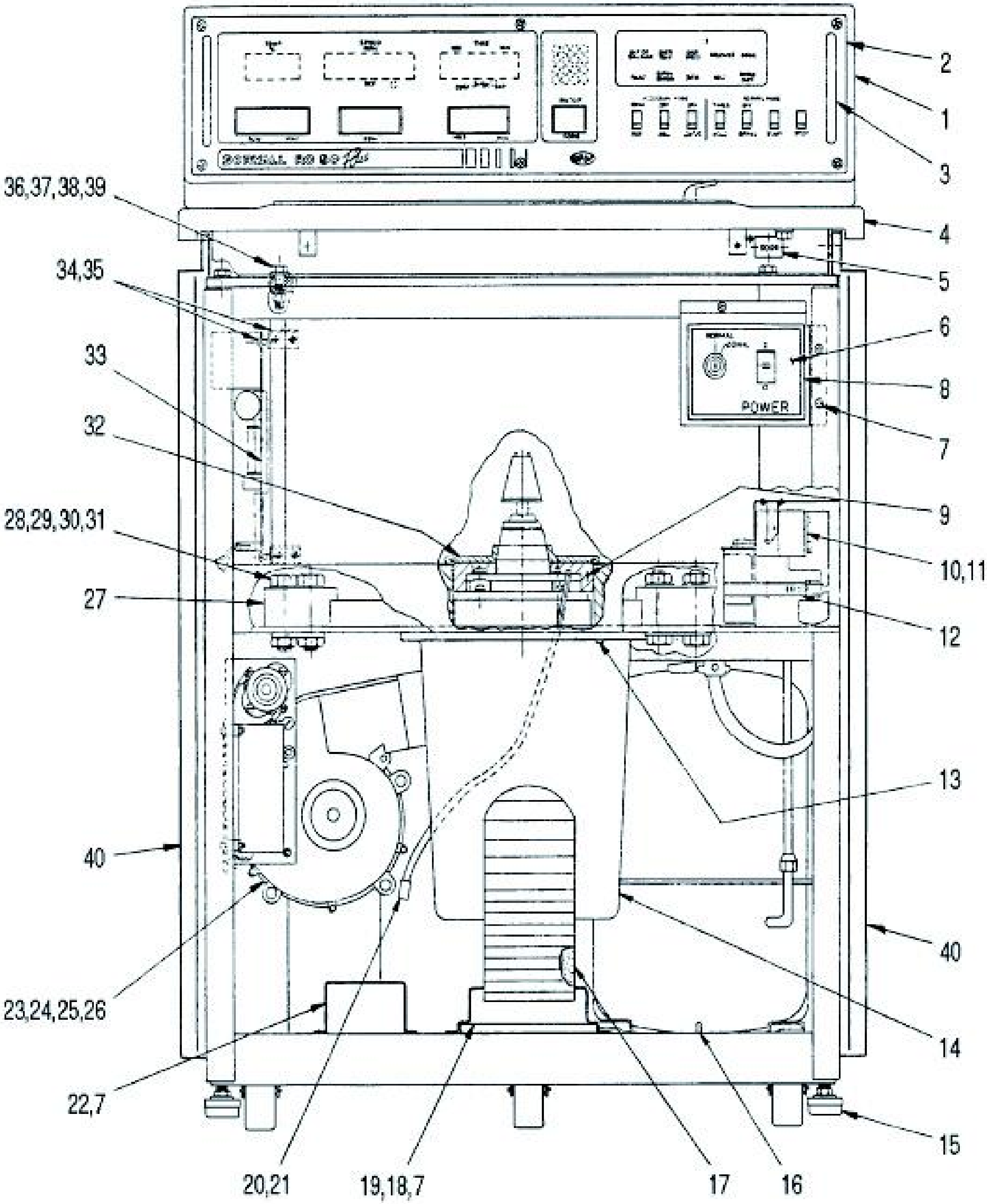


Figure 13-14. RC5C PLUS Assembly, Front View

Item No.	Description	Part No.
1	RC-5C PLUS Console Assembly	74027
2	Front Console Panel Assembly	74521
3	Front Console Panel Handle	**55531**
4	Deck Assembly	**74025**
5	Door Button	**50689**
6	Key Switch Panel Assembly	**74520**
7	Screw, Pan Head with Lockwasher, Phillips, SST #8-32 ~ 3/8 long	91420
8	Bezel, Circuit Breaker Panel	55508
9	Foam Insulating Disc	**50415**
10	Relay, Potential	**91489**
11	Screw, Pan Head with Lockwasher. Phillips, SST, #8-32 x 1/4 long	62828
12	Bracket, Adjustable Band	**91057**
13	Cap Screw, Hex Head with Lockwasher, SST, 1/4-20 x 1 long	91455
14	Silencer Assembly	**74074**
15	Leveling Pad	**60619**
16	Cap Screw, Socket Head - Hex, STL, 1/4 ~ 20 x 1-1/4 long	62844
17	Exhaust Duct Assembly	**74035**
18	Filter Assembly (includes foam strips)	**74037**
19	Filter Holder	74038
20	Imbalance Detector Harness Assembly	**50778**
21	Connector	68683
22	Bracket	56058
23	Blower Motor Assembly	**74119**
24	Bracket, Blower Motor	**74047**
25	Screw, indented Hex with Lockwasher, STL, 1/4-20 x 1/2 long	**66543**
26	Nut, Hex with Lockwasher, #8-32	91482
27	Hold Down Block (Guard to Base)	20839
28	Bolt, Hex Head, Grade 5 STL, Cad Pl, 5/8-11 x 1-1/2 long	65646
29	Flat Washer, 5/8. STL, Cad Pl, 1-1/4 O.D. x 41/64 I.D. x 1/16 thick	65647
30	Split Lockwasher, 5/8, STL, Cad Pl	65648
31	Nut, Hex, Jam, Grade 5, STL, 5/8-11	64784
32	Gyro Cover Seal	**50414**
33	High Voltage Interface Printed Circuit Board Assembly	**50710**
34	Bracket, High Voltage Interface PC. Board	50768
35	Screw, Pan Head with Lockwasher, Phillips, STL Zinc Plated, 6-32 x 1/2	91403
36	Nut, Hex, STL, Zinc Plated, 3/8-16 x 21/64 thick	91385
37	Split Lockwasher, STL, Zinc Plated, 3/8 x 0.070 thick	91380
38	Flat Washer, 13/32 I.D. x 13/16 O.D. x 1/16 thick	61627
39	Cap Screw, Hex Head, STL, Zinc Plated, 3/8-16 x 1-1/2 long	91450
40	Panel Assembly, Right Side and Left Side	**74111**
41	RC5B+/5C+ Preventative Maintenance Kit	**12011**

Table 13-14. RC5C PLUS Assembly, Front View

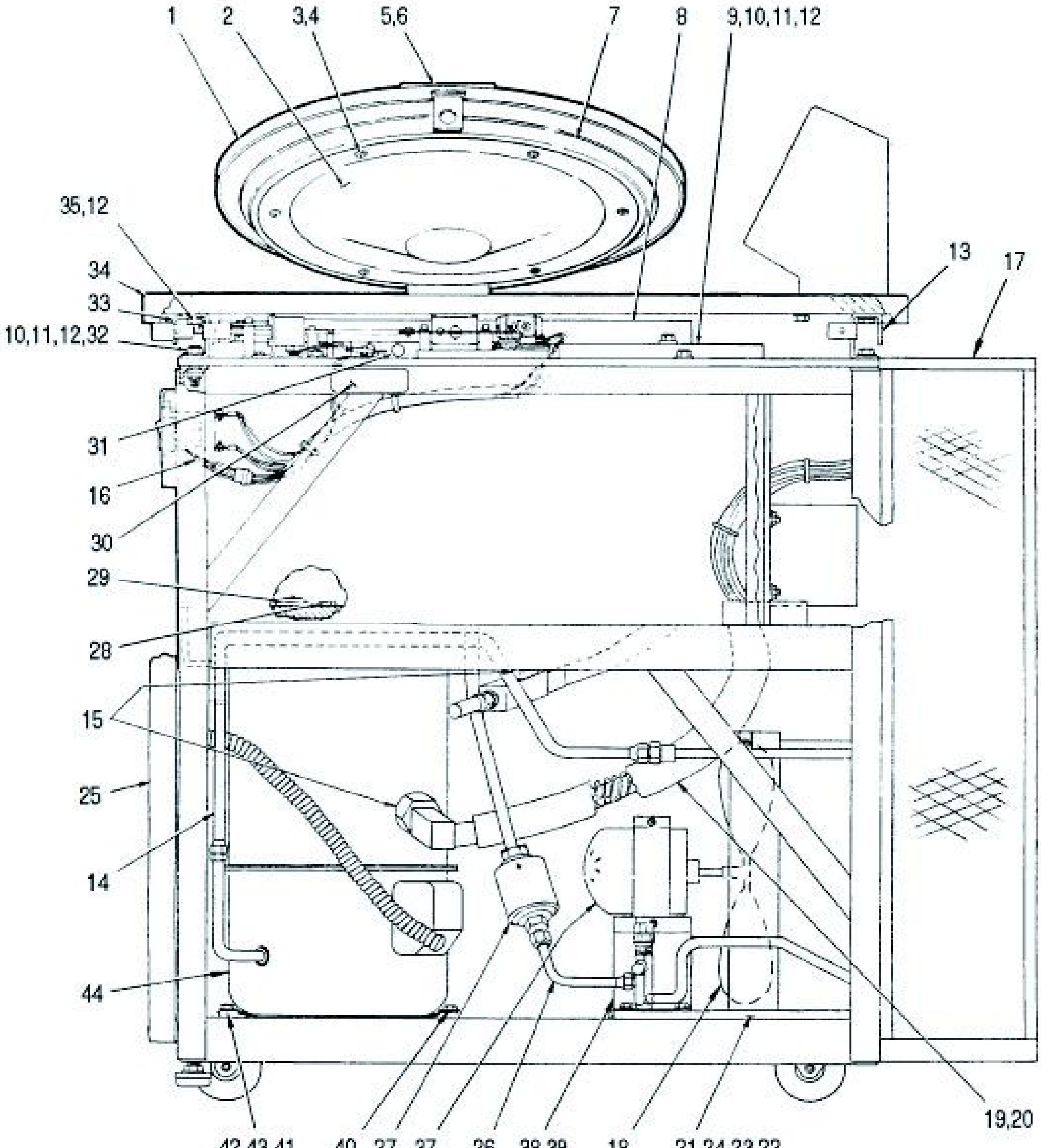


Figure 13-15. RC5C PLUS Assembly, Right View

Item No.	Description	Part No.
1	Door Assembly	**74033**
2	Diffuser Assembly	**74034**
3	Washer, Finishing, SST, #10	**60683**
4	Screw, Wood, OvalHead, Phillips, SST, #19 x 1-1/4 long	**65676**
5	Door Handle	**74028**
6	Cap Screw, Flat Head, Socket Hex, Black Oxide, #8-32 x 1 long	**66982**
7	Upper Door Seal	**50473**
8	Shroud	50094
9	Evaporator Top Plate	**50610**
10	Cap Screw, Hex Head, STL, 3/8-16 x 1-1/2 long	91450
11	Flat Washer, 3/8, STL, Cad Pl, 13/32 I.D. x 13/16 O.D. x 1/16 thick	61627
12	Split Lockwasher, 3/8, STL, STL, Zinc Plated	91380
13	Top Deck Support Assembly, Rear	50616
14	Tube Assembly (Compressor to Condenser)	74115
15	Seal, Teflon ( ) Fiber	**61768**
16	Harness, Keyswitch Assembly	74558
17	Backpack Assembly	**74316**
18	Fan Blade	**91362**
19	Suction Tube Assembly	74068
20	Suction Line Insulation (5-1/2 inches)	20588
21	Condensing Unit Assembly	74081
22	Flat Washer, 1/4, STL, Zinc Pl, 0.281 I.D. x 0.734 O.D. x 0.063 thick	91366
23	Split Lockwasher, SST, 1/4	63019
24	Cap Screw, Hex Head, STL, 1/4 ~ 20 x 1-1/2 long	64281
25	Front Panel Assembly with Insulation	**74112**
26	Tube Assembly (Valve to Filter Dryer)	74114
27	Filter Dryer	**71470**
28	Floor Temp Sensor Assembly	**74596**
29	Air Temp Sensor Assembly	**74579**
30	Label, High Voltage	**61223**
31	Cork, #4	66633
32	Nut, Hex, STL, Zinc Plated, 3/8-16	91385
33	Top Deck Support Assembly, Front	50430
34	Deck Assembly	**74025**
35	Screw, Hex Head, 3/8-16 x 3/4 long, STL, Cad Pl	64743
36	KSB Plug, Outer (Not Shown)	**20972**
37	Condenser Motor Fan	**91392**
38	Bracket, Condenser Motor Fan	**56277**
39	Screw, Indented Hex with Lockwasher, STL, 1/4-20 x 1/2 long	66543
40	Screw, Indented Hex with Lockwasher, STL, 5/16-18 x 1/4 long	91369
41	Grommet, Compressor	91471

Table 13-15. RC5C PLUS Assembly, Right View

Item No.	Description	Part No.
42	Screw, Indented with Lockwasher, STL, 5/16-18 x 1-3/4 long	66526
43	Sleeve, Compressor	91472
44	Compressor	91386

Table 13-15. RC5C PLUS Assembly, Right View (continued)

Item # Figure 13-15	Model Starting Serial # Ending Serial # Refrigerant	RC-5C Plus 9300322 9402188 HP-80 Original Configuration	RC-5C Plus 9303251 9402188 HP-62 Upgraded after 7/99 Replacement Parts*	RC-5C Plus 9402189 9503875 HP-62 Original Configuration	RC-5C Plus 9503876 9901464 HP-62 Original Configuration	RC-5C Plus 9901465 Present HP-62 Original Config.**
27	Filter Drier	**91470**	**74781**	**56200**	**74174**	**74346**
15	Suction Line	**12988**	**74347**	**12988**	**12988**	**74347**
37	Fan Motor	**91392**	**91392**	**91392**	**91392**	**91392**
	Run Capacitor	**91474**	**92733**	**91983**	**91983**	**92733**
	Start Capacitor	**91475**	**92734**	**91981**	**91981**	**92734**
	Potential Relay	**91489**	**92732**	**91986**	**91986**	**92732**
18	Fan Blade	**91362**	**91897**	**91897**	**91897**	**91897**
21	Condenser Assembly (condenser only)	**74081**	**74081**	**56217**	**56217**	**56217**
	Teflon Seal (small)	**--------**	**66952**	**66952**	**66952**	**66952**
	Teflon Seal (large)	**61768**	**61768**	**61768**	**61768**	**61768**
44	Compressor	**74780**	**74195**	**56222***	**56222***	**74195**
	Evaporator	**12236**	**12236**	**74173**	**74173**	**74173**
14	Tube, Comp. to Condenser	**74115**	**74782**	**56198**	**56198**	**74348**

* All RC-5C Plus replacement refrigeration parts use Suva HP-62 refrigerant.
** If the compressor was replaced AFTER July 1999 use the far right column of the chart for replacement parts.

Figure 13-15-1 RC-5C Plus refrigeration parts

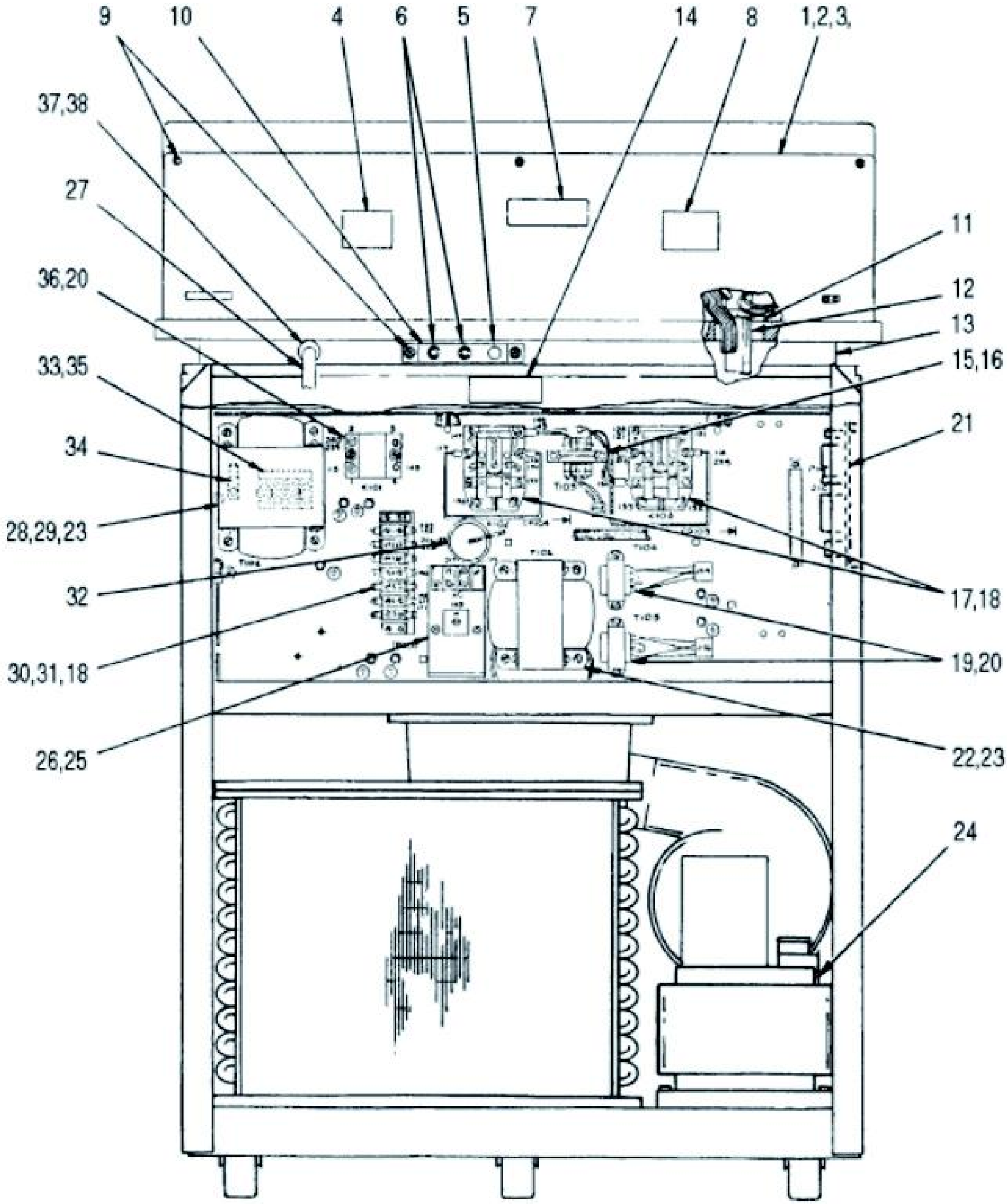


Figure 13-16. RC5C PLUS Assembly, Rear View

Item No.	Description	Part No.
1	Console Backplate	74026
2	Cap Screw, Socket Head, STL, 1/4-20 x 3/4 long	91452
3	Lockwasher External Tooth, SST, #1/4	63937
4	Nameplate	74554
5	Plug, Hole, Snap-in, 3/8 inch, Brass, Chrome Plated	66676
6	Circuit Breaker, 1 Amp, 250 Vac	**66760**
7	Label, WARNING	**68868**
8	Label, CAUTION	67369
9	Screw, Pan Head with Lockwasher, Phillips, SST, 8-32 x 3/8 long	91420
10	Breaker Bracket	50624
11	Clamp, Cable, Flat, Adhesive Mount	67294
12	Control Cable Assembly	**50806**
13	Support Assembly, Top Deck (Rear)	50616
14	Label, Danger, High Voltage	**61223**
15	Transformer Assembly, Current Limiting	**50784**
16	Screw, Pan Head, Slotted, STL Cad Pl	91483
17	Relay, Power, Heavy Duty, 24 Vdc	**66922**
18	Screw, Pan Head, Phillips, STL, Zinc Pl, 8-32 x 3/4 long	91481
19	Transformer Subassembly, Relay Panel	**50799**
20	Screw, Pan Head with Lockwasher, SST, Zinc Pl, 8-32 x 1/4 long	91493
21	Power Supply PC. Board Assembly	**74777**
22	Transformer Assembly	**74073**
23	Nut, Hex with Lockwasher, SST, #10-32	91410
24	Reactor Assembly	**74075**
25	Rectifier Assembly with Bracket	**74532**
26	Nut, Hex with Lockwasher, STL, Zinc Pl, #8-32	91482
27	Power Cord	**64065**
28	Transformer Assembly	**76522**
29	Flat Washer, SST, #10	61652
30	Terminal Block, Barrier Type, 30 Amp Special	65997
31	Insulator, Terminal Block	66112
32	Gromment, Neoprene, 1-5/16 I.D. x 1-11/16 O.D. x 5/16 thick	68059
33	Terminal Strip, 4 Pole, 40 Amp, 380/450V	**67415**
34	Connector, Cable, #14-6 AWG Range, #10 MTG	65699
35	Insulator, Terminal Block	50352
36	Relay, Solid State, 3-28 Vdc	**68794**
37	Strain Relief	**68037**
38	Nut for Strain Relief	**68038**
39	Line Filter	**92005**

Table 13-16. RC5C PLUS Assembly, Rear View

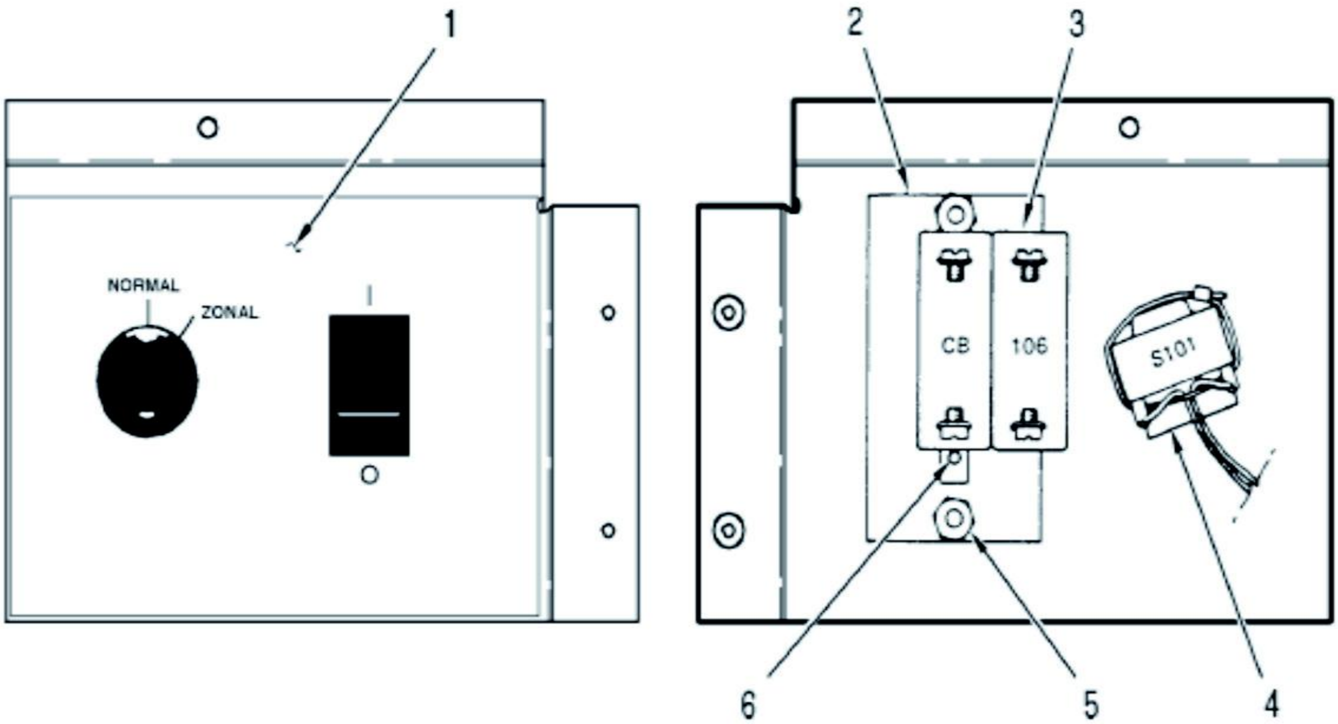


Figure 13-17. Keyswitch Panel Assembly

Item No.	Description	Part No.
1	Overlay, Keyswitch Panel	**74517**
2	Plate, Mounting, Circuit Protector	**50097**
3	Circuit Protector, Two Pole, 30 amp	**91476**
4	Key Switch Assembly	**50798**
5	Hex Nut with Lockwasher, SST, #10-32	91410
6	Screw, Flat Head, Slotted, SST, UNC, #6-32 x 1/4 long	60674
---	Key	**91499**

Table 13-17. Keyswitch Panel Assembly

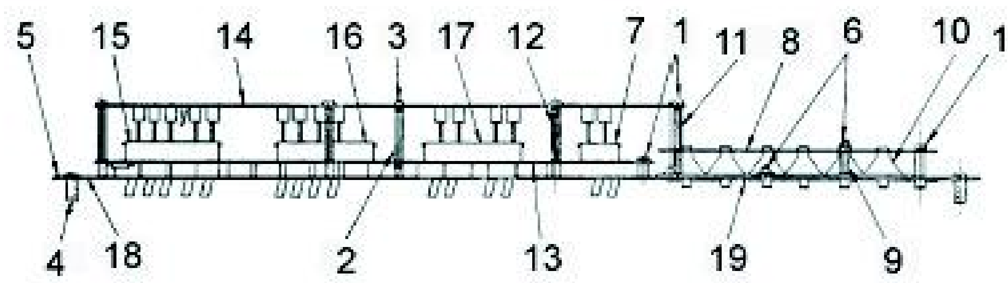


Figure 13-18. Front Console Panel Assembly (Top View)

Item No.	Description	Part No.
1	Screw, Pan Head, Slotted, SST, UNC, #6-32 x 3/8 long	91417
2	Standoff, Female, 1/4 Hex x 2-1/8 long, #6-32	90925
3	Screw, Nylon, Pan Head, Phillips, UNC, #6-32 x 3/8 long	91479
4	Front Console Panel Handle	**55531**
5	Front Panel Console	74535
6	Nut, Hex with Lockwasher, SST, #6-32	91445
7	Switch, Mininlever, Panel Mount, 2 Station, Rotor Code	**92252**
8	Switches and Indicators Printed Circuit Board Assembly	**50685**
	Switches S1, S2, S3, S4, Toggle, PC Mount	**67183**
	Switch S5 Toggle, PC Mount	**68048**
	Switch S6 Toggle, PC Mount	**68047**
	Switch S7 Toggle, PC Mount	**68049**
	Incandescant Lamp, DS1 through DS 12	**83187**
9	Standoff, Male - Female, 1/4 Hex x 1 inch long, #6-32, SST	50756
10	Reflector, Light	**50645**
11	Standoff, Female, 1/4 Hex x 1/4 long, #6-32, SST	**68046**
12	Standoff, Male - Female, 1/4 Hex x 1-5/8 long, #6-32, SST	67337
13	LED Display Circuit Board Assembly	**50679**
14	Microcomputer Printed Circuit Board Assembly	**56266**
15	Switch, Minilever, Panel Mount, 6 Station, TEMP	**92253**
16	Switch, Minilever, Panel Mount, 5 Station, SPEED	**92251**
17	Switch, Minilever, Panel Mount, 5 Station, TIME	**92250**
18	Front Panel Overlay	74516
19	Rotor Label I.D. Sticker	**74522**
19	Rotor Label I.D. Sticker (CE Only)	**74750**
- - -	Harness Assembly, Main (Not Shown)	**74538**
- - -	Cable Assembly, Control (Not Shown)	**50806**

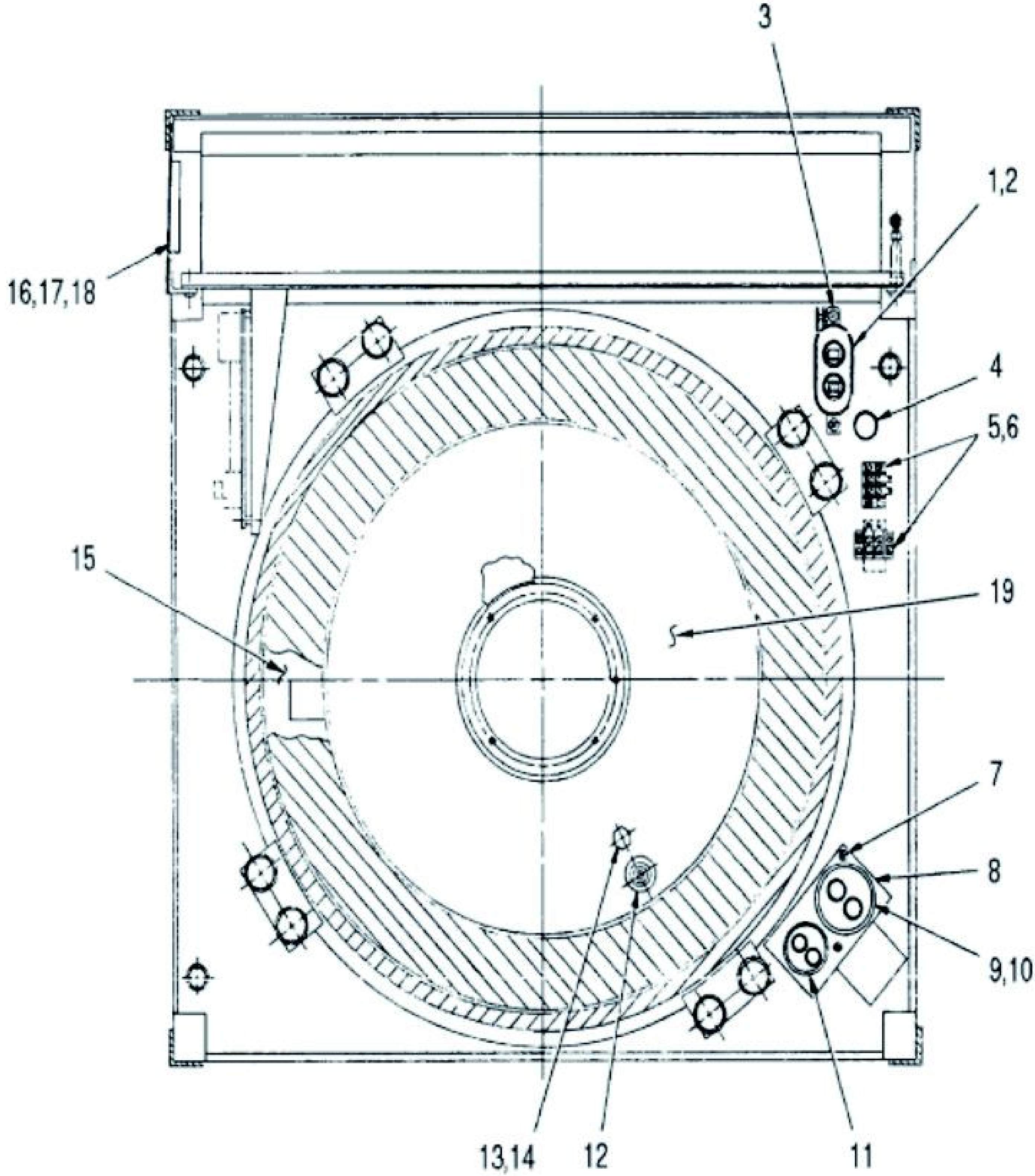


Figure 13-19. RC5C PLUS Evaporator Assembly (Top View)

Item No.	Description	Part No.
1	Capacitor, Motor Run, 20 uF	**66961**
2	Bracket, Capacitor, Universal Wrap	66957
3	Screw, Pan Head with Lockwasher, Phillips, SST, 8-32 x 3/8 long	91420
4	Bushing, Snap-in	**91430**
5	Terminal Block, Barrier Type, 2 Terminal, 15 amp	**64723**
6	Screw, Pan Head with Lockwasher, SST, UNC, 6-32 x 3/4 long	91456
7	Screw, Pan Head with Lockwasher, SST, 10-32 x 1/2 long	91405
8	Bracket, Capacitor	76262
9	Capacitor, Start 176-216 uF 330 V, 15 K ohm	91475
10	Jumper Assembly	**74144**
11	Capacitor, Run, 25 uF, 370 V	91474
12	Sensor Assembly, Air Temperature	**74579**
13	Sensor Assembly, Floor Temperature	**74596**
14	Grommet, Neoprene	63875
15	Insulation, Evaporator	**20094**
16	Power Supply Printed Circuit Board Assembly	**74777**
17	Screw, Pan Head with Lockwasher, STL, Zinc PI, 6-32 x 1/4 long	91486
18	Standoff, Round, 6-32 x 1/2 long	68097

Note: For items 9 & 11 see Table 13-15-1 on page 13-33.

Table 13-19. RC5C PLUS Evaporator Assembly (Top View)

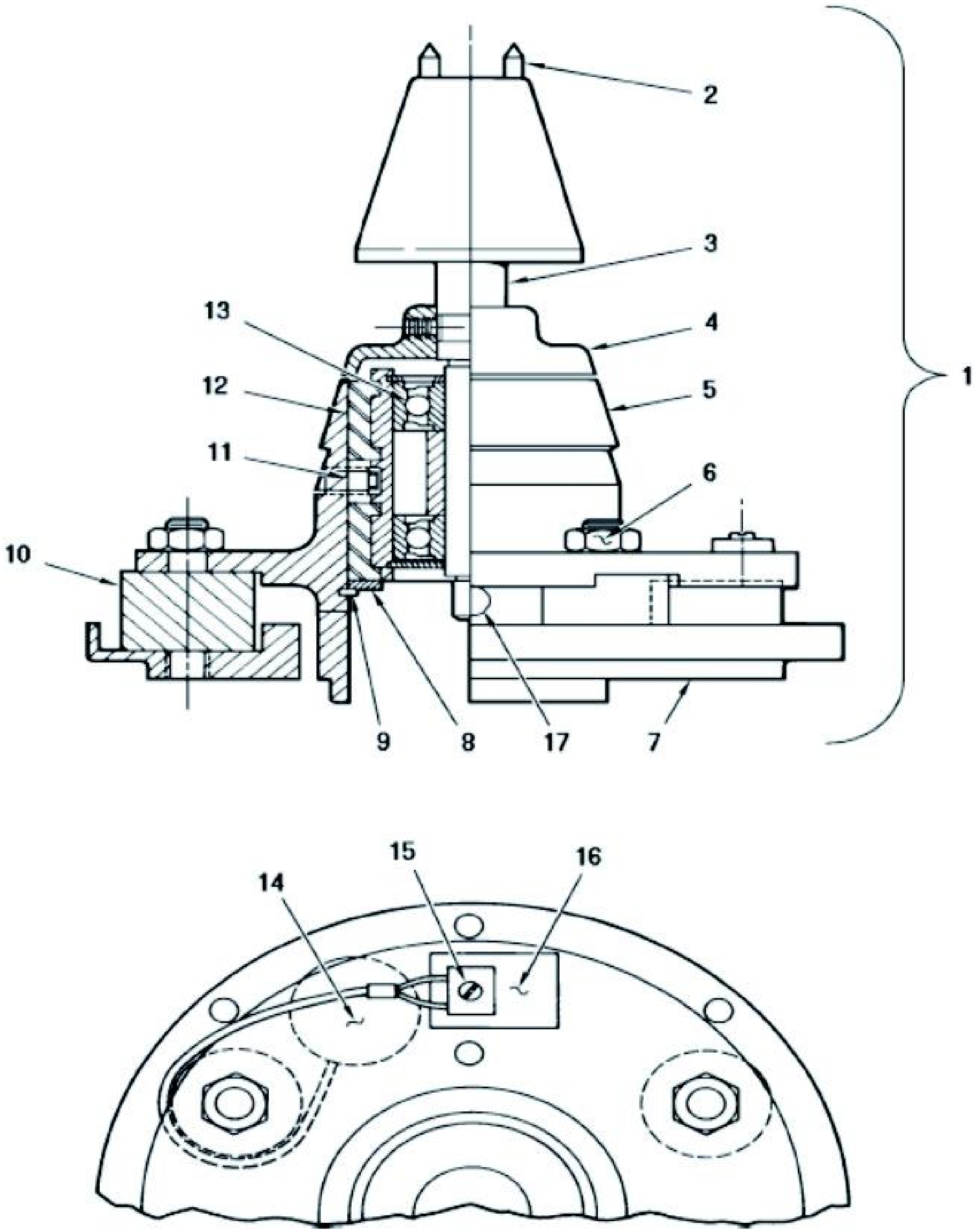
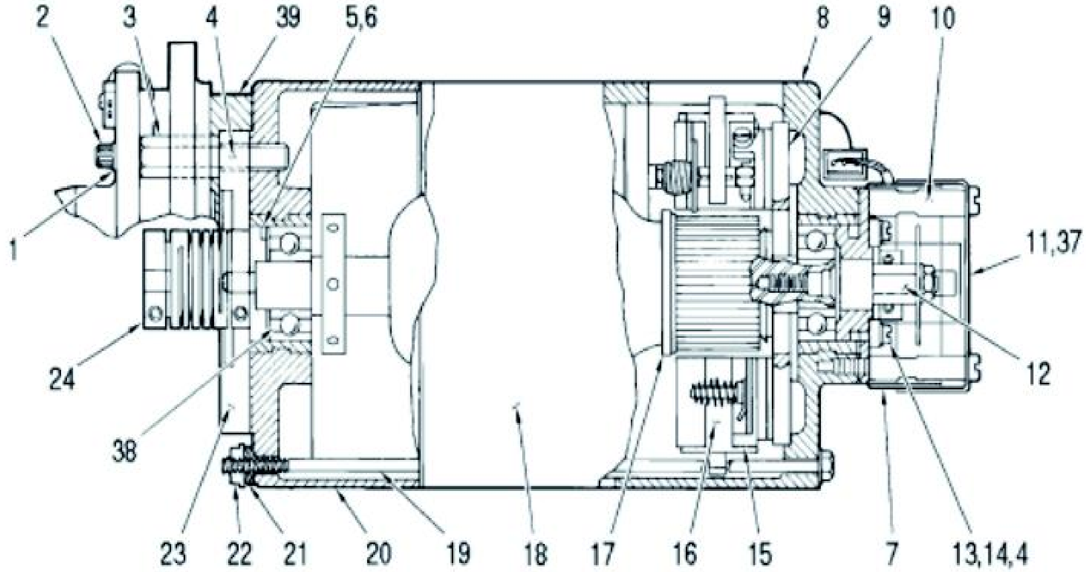


Figure 13-20. RC5C PLUS Drive Assembly

Item No.	Description	Part No.
1	RC-5C PLUS Gyro Action Drive Assembly	**12817**
2	Pin, Tapered Spindle	**204742**
3	Spindle Assembly	12348
4	Slinger, Sealing	50578
5	Mounting Plate, Upper	50812
6	Nut, Hex, SST, UNC, 5/16-18	67273
7	Mounting Plate, Lower	50407
8	Washer, Support	50409
9	Retaining Ring	**67270**
10	Mount, Flex-Bolt	**50408**
11	Set Screw, Hex Socket, SST, UNC, #1/4-20 x 3/8 long	**67272**
12	Housing Assembly, Bearing	50405
13	Bearing Replacement Kit	**12342**
14	Imbalance Detector	**50843**
15	Screw, Pan Head, Slotted, SST, UNC, #2-56 x 1/4 long	63818
16	Insulator	67710
17	Plug, Access Hole	**67341**

Table 13-20. RC5C PLUS Drive Assembly



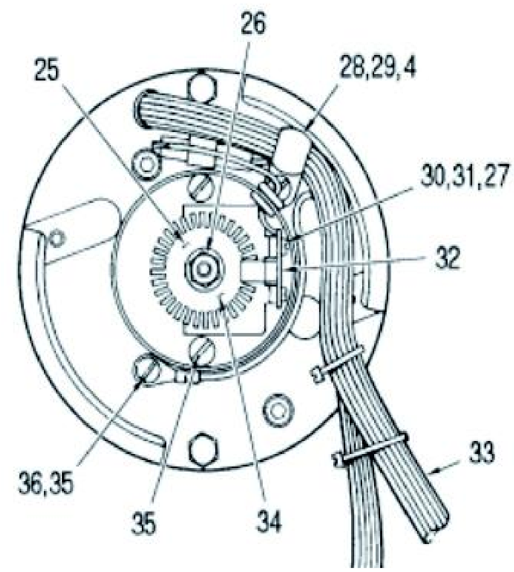


Figure 13-21. RC5C PLUS Motor Assembly (Brush Motor)

Item No.	Description	Part No.
- - -	RC-5C PLUS Motor Assembly	**74510**
1	Split Lockwasher, #10, SST, 0.040 thick	63016
2	Cap Screw, Socket Head Hex, SST, UNF, #10-32 x 3/4 long	60568
3	Standoff, 7/16 Hex, Male 1/2-20 Female #10-32	50418
4	Adhesive, Sealant, Loctite, #222	**65811**
5	Washer, Spring, Wavy, 1.051 I.D. x 1.351 O.D. x 0.99 H	67281
6	Shim, 0.010 thick	**20483**
6	Shim, 0.020 thick	**20509**
6	Shim, 0.040 thick	**20510**
7	Dust Cover, Bottom	**74565**
8	End Bell, Lower, Motor	74142
9	Disc, Insulating, Motor	**20478**
10	Standoff, Dust Cover, 5/16 diameter, #10-24 x 1-1/4 long	**50849**
11	Dust Cover, Top, Optical Pick - up	**74564**
12	Shaft, Optical Pick - up	**74566**
13	Screw, Pan Head, Phillips, SST, #5-40 x 1/4 long	61498
15	Holder Assembly, Plate & Brush, RC-5C PLUS	74062
16	Brush, Commutator, 3/8 ”	**74196**
16	Brush, Commutator, 1/4 ”	**12284**
17	Armature Assembly includes	**74051**
	Armature	50419
	Slinger	74050
	Ball Bearing, Extra Quiet	90984
	Slinger	204672
	Wafer Insulation	50824
	Bearing Spacer	50088
18	Housing & Stator Assembly, Motor (Machining)	**20612**
19	Rod, Tie, Motor	20507
20	Bell, End, Upper, Motor	50421
21	Washer, Spring, Belleville, 0.19 I.D. x 0.375 O.D. x 0.03 H x 0.02 thick	**61980**
22	Nut, Flange, Low Carbon STL, Zinc Plated, UNC #10-24	91442
23	Plate, Preload	50416
24	Coupling Assembly	**12345**
25	Disc, Optical Pick - up	**50735**
26	Nut, Hex, with Lockwasher, SST, #10 - 32	91410

Table 13-21. RC5C PLUS Motor Assembly (Brush Motor)

27	Flat Washer, #4, SST, 1/8 I.D. x 1/4 O.D. x 0.022 thick	61072
28	Clamp, Cable, Plastic, 1/2 inch dimeter	91492
29	Screw, Pan Head, Phillips, SST, UNC, #8-32 x 3/8 long	91420
30	Screw, Pan Head, Slotted, SST, UNC, #4-40 x 3/16 long	62913
31	Split Lockwasher, #4, SST, 0.031 thick	63006
32	Tachometer Pick - Up Printed Circuit Board Assembly	**55635**
33	Harness Assembly, Motor	74533
34	Bracket	**50618**
35	Screw, Pan Head, with Lockwasher, SST UNC, #10-24 x 1/4 long	91424
36	Lockwasher, #10 External Tooth, SST	67896
37	Silicone Tape for Dust Cover (refer to callout 11)	**90791**

Table 13-21. RC5C PLUS Motor Assembly (Brush Motor)

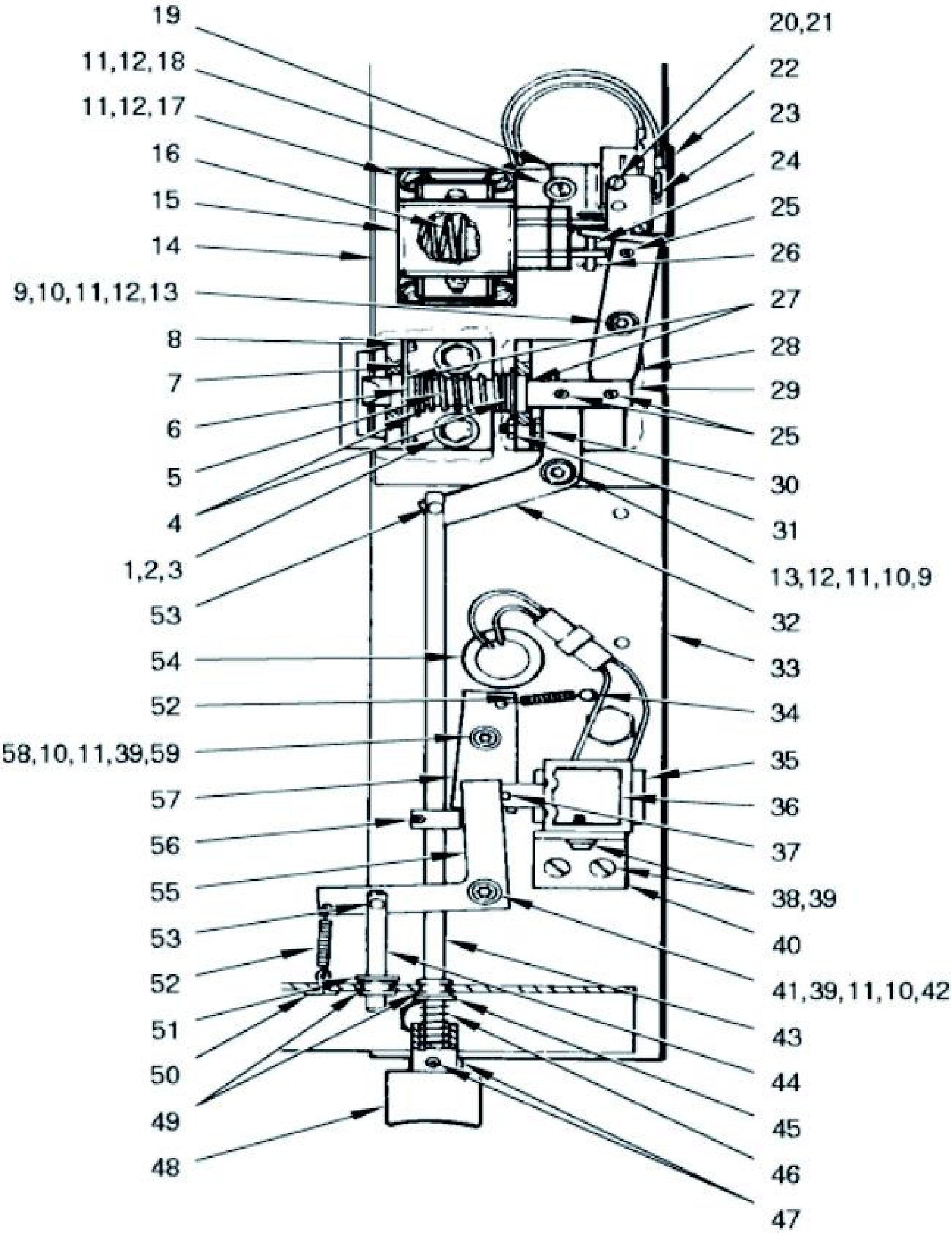


Figure 13-22. RC5C PLUS Door Interlock Assembly (Part A)

Item No.	Description	Part No.
1	Flat Washer, STL, 5/16,11/32 I.D. x 11/16 O .D. x 1/16 thick	60885
2	Split Lockwasher, 5/16, SST, 0.078 thick	63023
3	Screw, Hex Head, STL, 5/16-18 x 1-1/4 long	64747
4	Flat Washer, 0.515 I.D. x 0.875 O .D. x 0.016 thick, SST, Cad PI	66341
5	Spring, Compression, 0.53 I.D. x 2.3 long, 0.038 Wire Diameter, SST	**50076**
6	Ring, Retaining, External, 1/2 inch Shaft Diameter	**62503**
7	Retainer, Bushing	50111
8	Screw, Pan Head, SST, Slotted, UNC #4-40 x 3/16 long	62913
9	Support, Linkage, Interlock	**50572**
10	Flat Washer, Nylon, 0.39 I.D. x 0.625 O.D. x 0.031 thick	**61889**
11	Flat Washer, #10, SST, 13/64 I.D. x 7/16 O.D. x 0.031 thick	61652
12	Split Lockwasher, #10, SST, 0.040 thick	60346
13	Cap Screw, Socket Hex Head, SST, UNRF, #10-32 x 1-1/4 long	90340
14	Weldment Assembly, Door Interlock	50077
15	Solenoid, Pull Type, Modified	**50870**
16	Compression Spring	68745
17	Cap Screw, Socket Hex Head, STL, UNF, #10-32 x 1/2 long	64301
18	Screw, Pan Head, Slotted, SST, UNF, #10-32 x 3/8 long	61597
19	Microswitch Bracket Assembly	50887
20	Screw, Pan Head, Slotted, SST, UNC, #4-40 x 5/8 long	62396
21	Split Lockwasher, #4, SST, 0.020 thick	63004
22	Insulator, Fish Paper, 1-19/32 x 1 x 0.015 thick	**62245**
23	Microswitch, SPDT	**66753**
24	Pin, Clevis, 0.187 diameter x 0.75 inch long	**68080**
25	Pin, Spring, Spiral, 1/8 diameter x 5/8 long	63238
26	Pin, Hitch, 0.042 diameter x 31/32 long	**67567**
27	Bearing, Nylon, Flanged, 1/2 I.D. x 7/32 long	**66314**
28	Link, Solenoid	**50870**
29	Plunger, Door Interlock	**50871**
30	Screw, Hex Head, SST, Unslotted, UNC, #6-32 x 5/8 long	68746
31	Nut, Hex, SST, #6-32	60074
32	Link, Manual Release	50869
33	Door Interlock Support Plate	50776
34	Post, Spring, 0.188 x 1.50 long	68161
35	Tape, Insulating, 1 inch x 1-1/2 inch	67710

Table 13-22. RC5C PLUS Door Interlock Assembly (Part A)

Item No.	Description	Part No.
36	Solenoid Assembly	**50803**
37	Pin, Spring, Self Locking, 0.093 x 0.62	67904
38	Screw, Binding Head, SST, #10-32 x 5/16 long	60855
39	Split Lockwasher, SST, #10 x 0.040 thick	60346
40	Bracket, Solenoid	50501
41	Cap Screw, Socket Head, SST, 10-32 x 1-7/8 long	67906
42	Spacer, Round, 0.194 I.D. x 1/2 O.D. x 1-7/16 long	68160
43	Rod, Door, Manual Release	50881
44	Rod, Solenoid Release	50522
45	Flat Washer, 1/4, STL, Zinc Plated, 0.281 I.D. x 0.734 O.D. x 0.063 thick	91366
46	Spring, Compression, 0.360 O.D. x 1.00 FL x 0.032 Wire	**67899**
47	Setscrew, Socket Head, Cup Point, STL, #10-32 x 3/16 long	**64342**
48	Button, Door Interlock	**50689**
49	Bearing, Nylon, Snap-in, Shaft Size 0.25 diameter	**63985**
50	Pin, Cotter, SST, 1/16 x 1/2 long	60315
51	Ring, Retaining, External, 1/4 shaft diameter	**67903**
52	Spring, External, 0.18 O.D. xl.001ongx0.018 Wire	**68209**
53	Pin, Cotter, Hairpin, SST, 0.092	**66979**
54	Bushing, Snap, 3/4 I.D., 1.0 Mounting Hole	68214
55	Arm, Solenoid Release	**50612**
56	Collar, Clamp Tite	68172
57	Link, Interlock	50502
58	Spacer, Round, 1/2 O.D. x 0.194 I.D. x 1-1/8 long	67900
59	Cap Screw, Socket Head, SST, #10-32 x 1-11/16 long	60580
---	Door Interlock Assembly (Items 1-32)	**50868**

Table 13-22. RC5C PLUS Door Interlock Assembly (Part A Coninued)

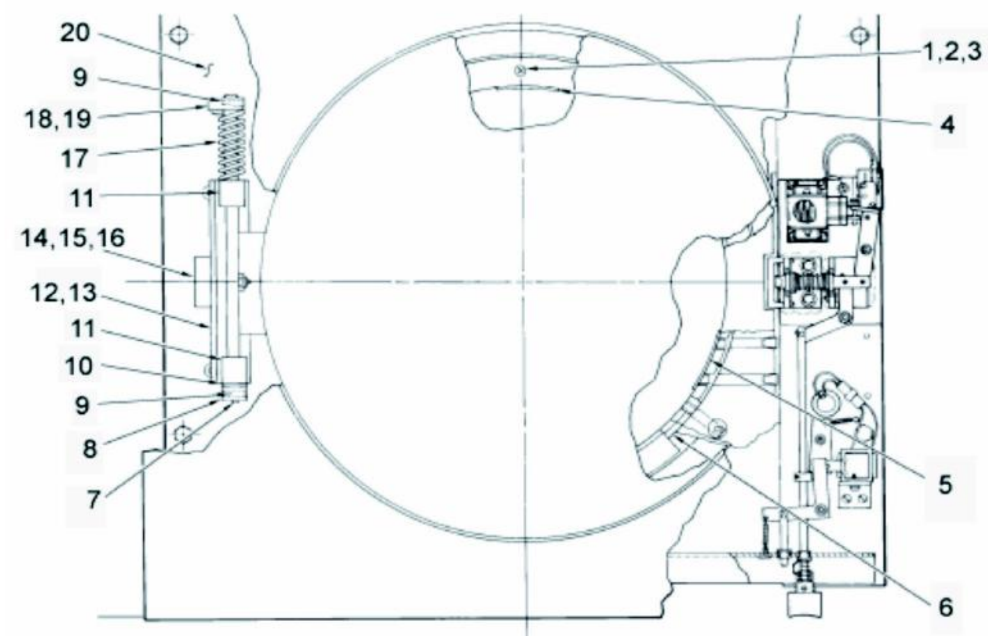


Figure 13-23. RC5C PLUS Door Interlock Assembly (Part B)

Item No.	Description	Part No.
1	Screw, Flat Head, Philips, Wood #10 x 1-3/4 long	65660
2	Seal Ring, Door, Lower	**50079**
3	Shroud	**74059**
4	Label, Rotation	**62541**
5	Stopper, KSB Outlet	20845
6	Lower Seal Ring	**20006**
7	Pin, Spring, Spiral 1/4 diameter x 1 long	**63240**
8	Stop, Door	**50101**
9	Pin, Spring, Spiral 3/16 diameter x 1 long	**63239**
10	Flat Washer, Nylon, 1/2 I.D. x 1 O.D. x 1/16 thick	66349
11	Block, Mounting, Shaft (Spring)	**50102**
12	Bracket, Mounting	50083
13	Shim	66183
14	Switch, Push Button, DPDT	**91457**
15	Nut, Thin Hex, Brass, 3/8-32	66668
16	Washer, Internal Tooth, SST, 3/8 x 0.388 I.D. x 0.687 O.D.	62033
17	Spring, Torsion, .55 I.D. x 2.8 long	**50106**
18	Setscrew Slotted, Cup Point, 1/4-20 x 7/8 long	**66743**
19	Retainer Spring	**50100**
20	Plate, Support, Hinge	50080

Table 13-23. RC5C PLUS Door Interlock Assembly (Part B)

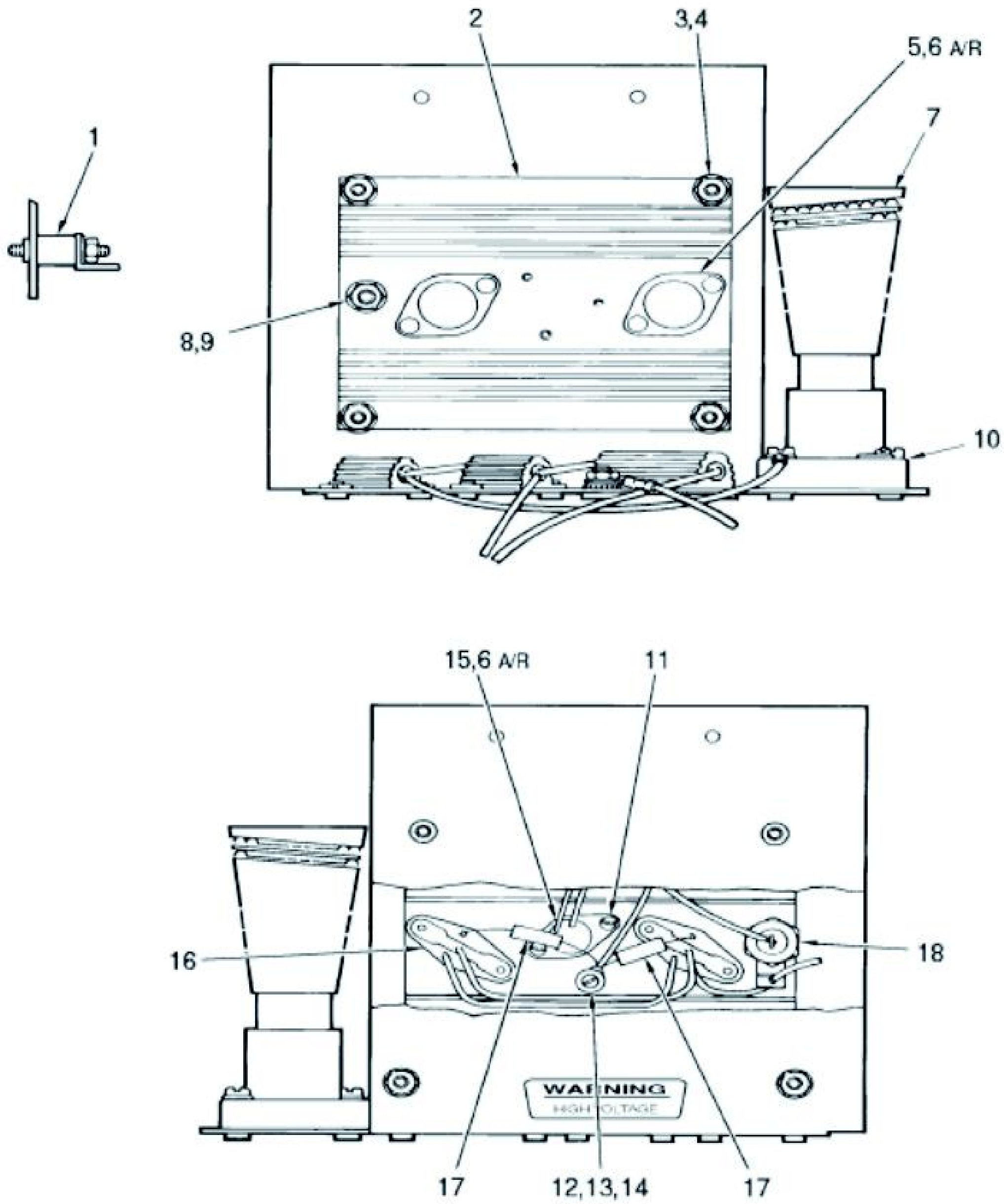


Figure 13-24. RC5C PLUS Constant Current Brake Assembly

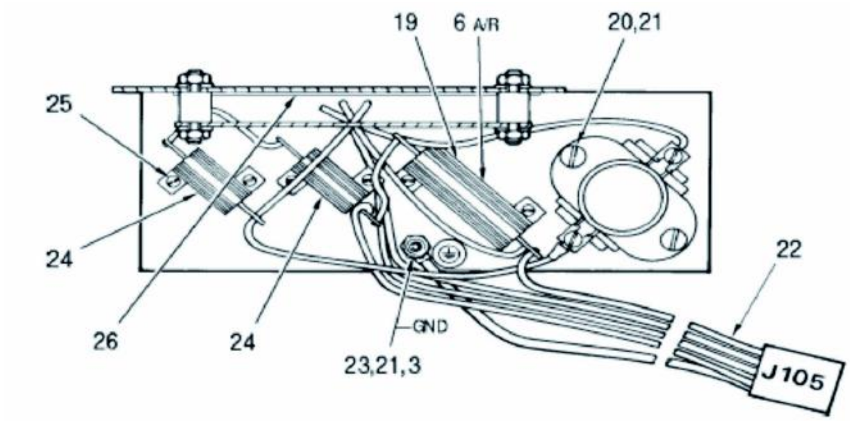


Figure 13-24. RC5C PLUS Constant Current Brake Assembly (Continued)

Item No.	Description	Part No.
- - -	Constant Current Brake Assembly	**50687**
1	Standoff, Male, #10-32, Delrim, Norelcom #51130-R-D-0 .500 with 0.375 long THRD	**68158**
2	Heatsink	50770
3	Nut, Hex, SST #10-32	60012
4	Flat Washer, SST, #10, 1 3/64 I.D. x 7/16 O.D. x 0.031thick	61652
5	Transistor, Power NPN, 2N30559	**20505**
6	Thermal Compound, 8 oz jar, Wakefield #120-8	**N/A**
7	Resistor, Braking, 2.7 Ohms, 1000 W	**61487**
8	Nut, Hex, SST, #1/4-20	61141
9	Split Lockwasher, #1/4, SST, 0.047 thick	63019
10	Receptacle, Braking, Resistor, 660 W, 250 V	**60406**
11	Screw, Pan Head, Slotted, UNC, #4-40 x 3/8 long	62395
12	Screw, Nylon, Pan Head, #6-32 x 1/2 long	67606
13	Flat Washer, Nylon, #10 x 1/8 thick	67383
14	Flat Washer, SST, 0.169 I.D. x 0.304 O.D. x 0.032 thick	63085
15	Thermostat	**68173**
16	Mounting Kit	65580
17	Resistor, Wirewound, 0.010 Ohms, 2 W	68171
18	Rectifier, Silicon, 100V, 1N249C	**68563**
19	Resistor, Wirewound, 0.5 Ohms, 30 W	68170
20	Screw, Pan Head, Slotted, SST, UNF, #10-32 x 3/4 long	61118
21	Split Lockwasher, #10 SST, 0.040 thick	63016
22	Harness Assembly, Constant Current Brake	50774
23	Lockwasher, External Tooth, #10, SST	67896
24	Resistor, Wire wound, 0.5 Ohms, 25 W	68169
25	Screw, Pan Head, Slotted, SST, UNC, #4-40 x 3/16 long	62913
26	Insulation, Fish paper	50879
27	Screw, Pan Head, Phillips, SST, UNF, #10-32 x 1/2 long	65768

Table 13-24. RC5C PLUS Constant Current Brake Assembly (Continued)

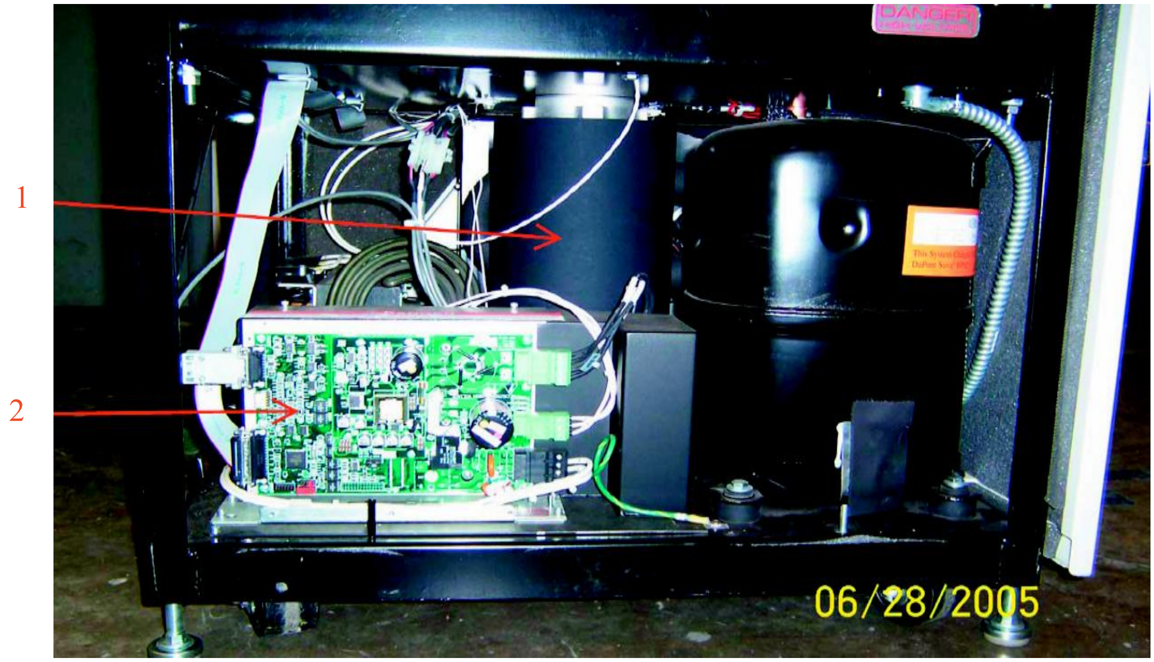


Figure 13-25 RC-5C Plus Brushless Lower Front View

Item No.	Description	Part No.
1	Motor Cooling Fan (located under the motor shroud)	**92697**
2	Drive Control Module	**73911**

Table 13-25 RC-5C Plus Brushless Lower Front View

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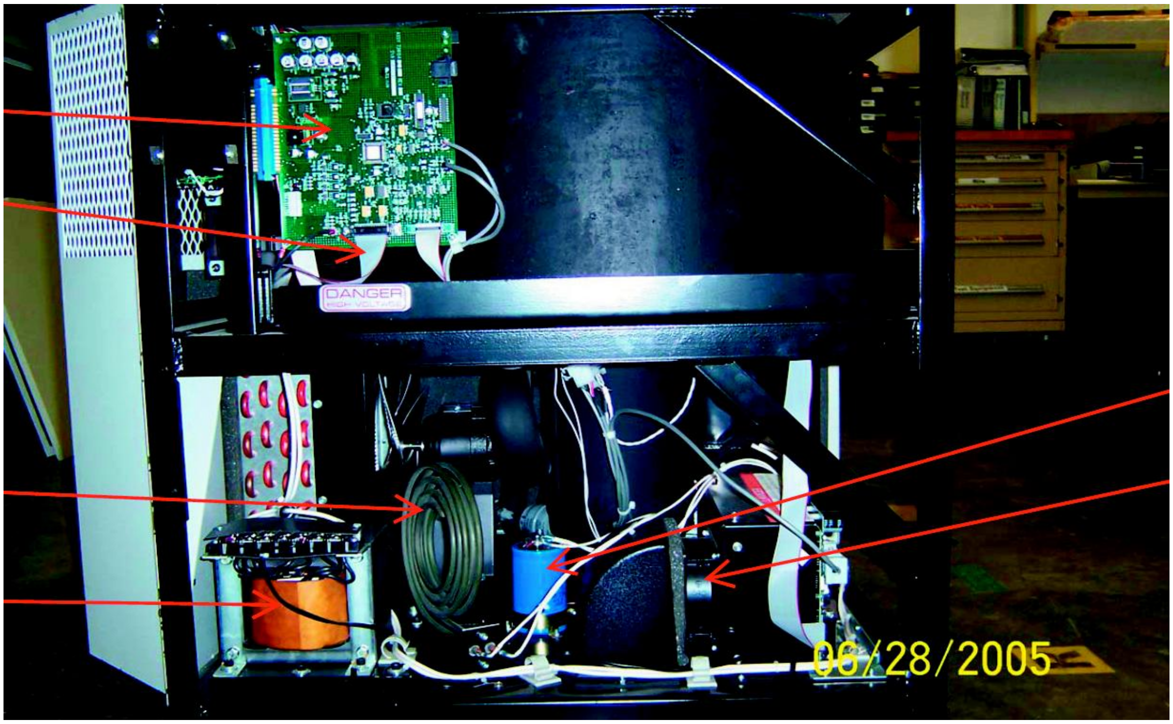
2
3
4


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Figure 13-26 RC-5C Plus Brushless Left Side View

Item No.	Description	Part No.
1	Drive Interface PCB	**73915**
2	Drive Interface Ribbon Cable	**73913**
3	Calrod Brake Resistor	**91046**
4	Drive Autotransformer	**92428**
5	Drive Control Cooling Fan	**69380**
6	Drive Capacitor	**92431**

Table 13-26 RC-5C Plus Brushless Left Side View

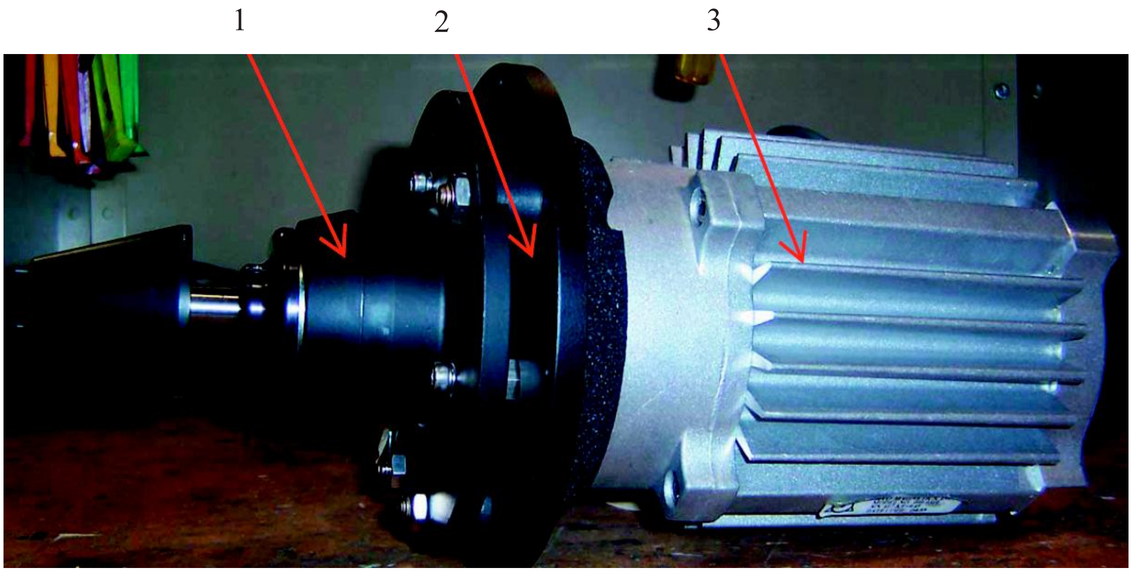

Figure 13-27 RC-5C Plus Brushless Motor / Gyro

Item No.	Description	Part No.
1	Gyro Action Drive Assembly	**12817**
2	Motor Coupling (not visible in the picture)	**12345**
3	Brushles Motor Assembly	**73938**

Table 13-27 RC-5C Plus Brushless Motor / Gyro