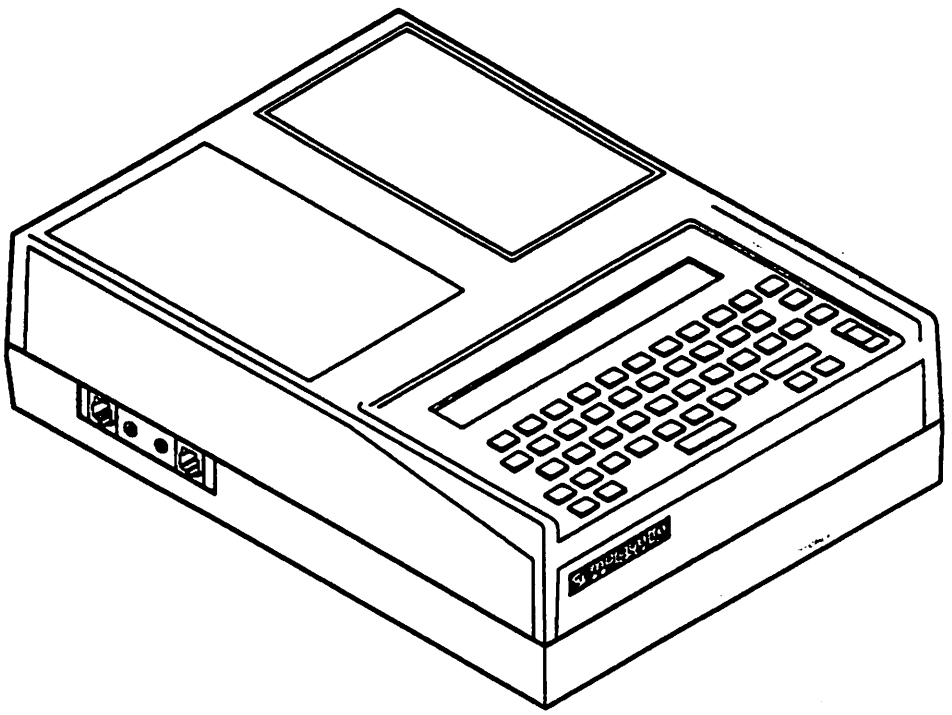
MAC® PC
Field Service Manual
(15th Edition)



marquette®
electronics

Marquette Electronics, Inc
8200 West Tower Avenue
Milwaukee, WI 53223 USA

Sales Offices

For all sales-related inquiries contact the offices listed below.

Eastern District

Marquette Electronics, Inc, Eastern District Office, 230 Commercial Street, Boston, Massachusetts, 02109. Telephone: (617) 523-2320 or (800) 262-4556. FAX: (617) 523-1759.

Southern District

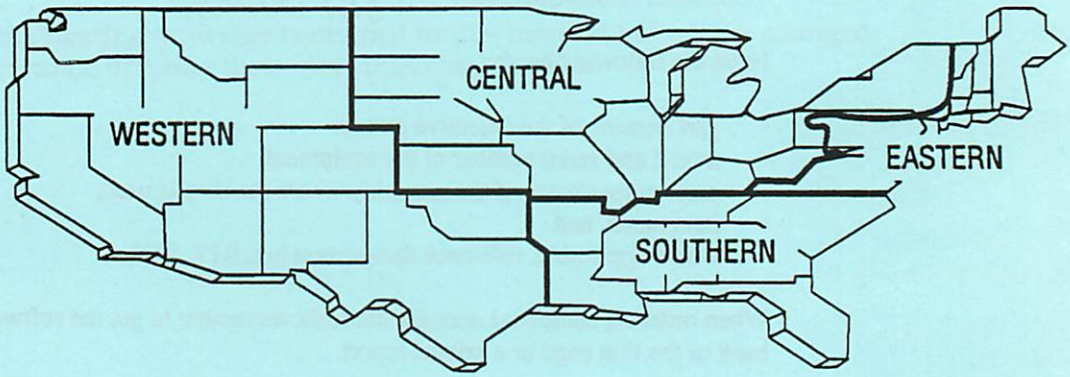
Marquette Electronics, Inc, Southern District Office, 4000 DeKalb Technology Center, Building 400, Suite 430, Atlanta, Georgia, 30340. Telephone: (404) 986-0106 or (800) 822-9950. FAX: (404) 986-0244.

Central District

Marquette Electronics, Inc, Central District Office, 165 North Arlington Heights Road, Suite 180, Buffalo Grove (Chicago), Illinois, 60089. Telephone: (708) 520-2390, (800) 558-3408 (except Illinois) or (800) 225-7150 (in Illinois). FAX: (708) 520-4218.

Western District

Marquette Electronics, Inc, Western District Office, 1010-C North Batavia Street, Orange (Los Angeles), California, 92667. Telephone: (714) 771-5741, (800) 762-0606 (except California) or (800) 537-9960 (in California). FAX: (714) 771-2426.



Canadian District

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TELEX: 3896966622 INGBELL TOR.

Western European District

Marquette Electronics, Inc, Western European District Office, 15, rue Rougemont, 75009 Paris, France. Telephone: (33) (1) 42 46 00 19. FAX: (33) (1) 48 01 04 41.
TELEX: (842) 532463F PARTNER.

Asia/Pacific District

Marquette Electronics, Inc, Asia/Pacific District Office, 1009-1010 Tai Yau Building, 181 Johnston Road, Wanchai, Hong Kong. Telephone: (852) 8381398. FAX: (852) 8381507 or (852) 572-9028. TELEX: 78069393 MEIAP HX.

Middle East/Africa District

Marquette Electronics, Inc, Middle East/Africa District Office, Themis Tower, Olympion Street, Limassol, Cyprus. Telephone: (357) (5) 355-516. FAX: (357) (5) 361-288.

Eastern European/ Latin America District

Marquette Electronics, Inc, 8200 West Tower Avenue, Milwaukee, Wisconsin, 53223. Telephone: 1-414-355-5000. FAX: 1-414-355-3790. TELEX: 297991 MEI UR.

Other Questions or Problems

For any other questions or problems, contact the main switchboard operator in Milwaukee, Wisconsin at 1-800-558-5120 or (414) 355-5000. The operator will direct your call to the person most able to assist you.

ECG Diagnostic Products

Warranty

MARQUETTE ELECTRONICS, INC., hereinafter referred to as MARQUETTE, warrants to repair or replace all new ECG Diagnostic Products sold by MARQUETTE or its authorized agents when shown to be defective in either materials or workmanship.

Warranty repairs or replacements will be made at customer premises at no charge for a period of one year from the date of shipment during the normal working hours of MARQUETTE except for the following products.

Warranty repair or replacement of defective MAC PC electrocardiographs, Holter recorders, and SEER recorders will be made for a period of one year from the date of shipment, provided they are returned to the factory with freight prepaid.

Excluded from this warranty are expendable supply items such as, but not limited to, electrodes, batteries, magnetic media, leadwires, patient cables, ink, and ribbons.

This warranty does not cover repairs or replacement parts which, in the opinion of MARQUETTE, are required as the result of abuse or misuse of the equipment, failure to maintain the equipment in the manner described in any applicable instructions, use of electrodes, batteries, magnetic media, or other supplies not recommended by MARQUETTE, or faulty devices connected to MARQUETTE equipment.

THIS WARRANTY IS GIVEN BY MARQUETTE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY AS TO MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

Michael J Ondak

PRESIDENT

Printed in USA

A0058B

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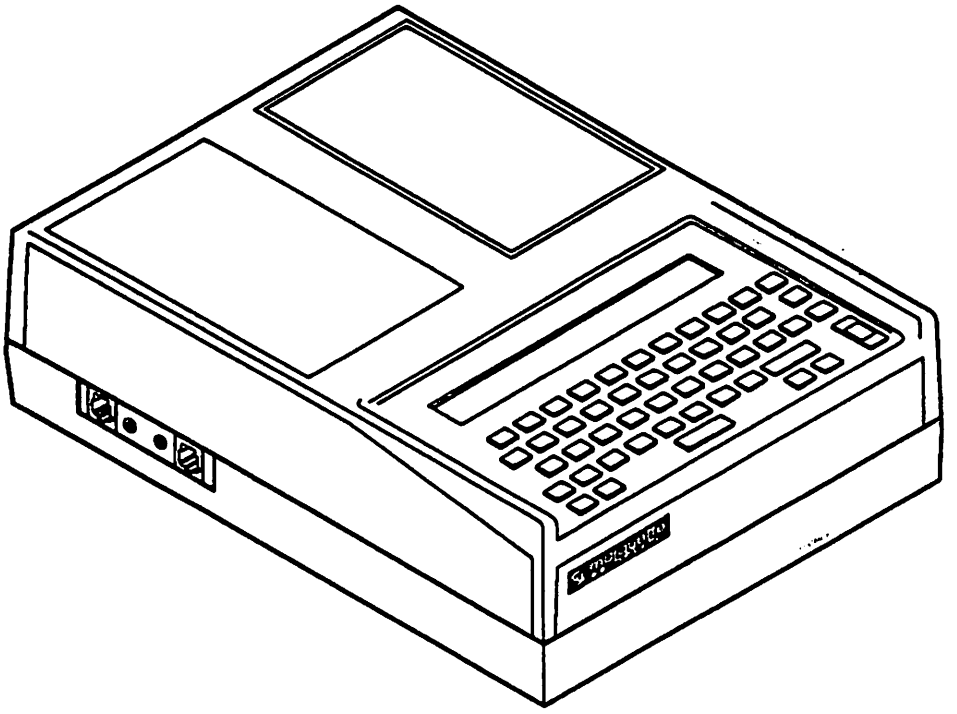
Field Service Manual

(15th Edition)



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Marquette Electronics, Inc
8200 West Tower Avenue
Milwaukee, WI 53223 USA

NOTE

Due to continuing product innovation, specifications in this manual are subject to change without notice.

NOTE

Some engineering drawings contained in this manual have been changed in appearance to make those drawings easier to use.

acct # 7836

How to Reach Us...

6th Edition

Following are telephone numbers and addresses for contacting various Service, Supplies, and Sales personnel.

Service Calls

To open a service call with Marquette Service, contact Service Dispatch at 1-800-558-7044.

Supply Products

Order supplies (leadwires, electrode paste, thermal paper, etc.) from MEI Service and Supplies, P.O. Box 9100, 100 Marquette Drive, Jupiter, FL, 33468-9100, Attn: Supplies. Telephone: 1-800-558-5102.

Service Parts and All Manuals

Order service parts (circuit boards, cables, software, etc.) and manuals from MEI Service and Supplies, P.O. Box 9100, 100 Marquette Drive, Jupiter, FL, 33468-9100, Attn: Service Parts. Telephone: ~~1-800-551-1957.~~ 558-7044 option 2

Have the following handy:

- part number of the defective part, or
- model and serial number of the equipment,
- part number/name of the assembly where the item is used,
- item name, and
- where applicable, reference designation (eg, R13, S12).

When ordering additional operator manuals, remember to get the software version from either the back of the title page or a printed report.

Tech Support—

Tech Support has the most current information about your equipment, and can provide assistance with any technical questions or problems.

Carts/Stress: 1-800-558-7072 **Holter:** 1-800-558-6802

MUSE Service (errors/hardware problems): 1-800-558-7070

MUSE Applications ("How to..." questions): 1-800-558-5120

48-Hour Turnaround Repair

Some Marquette products (MAC PC, acquisition modules, and Holter recorders) are repaired on a 48-hour turnaround basis. Send items for 48-hour repair to MEI Service and Supplies, P.O. Box 9100, 100 Marquette Drive, Jupiter, FL, 33468-9100, Attn: 48-Hour Turnaround Repair. Telephone: 1-800-552-3246.

Diagnostic Hardware Repair

Send all items except 48-hour turnaround repair items to MEI Service and Supplies, P.O. Box 9100, 100 Marquette Drive, Jupiter, FL, 33468-9100, Attn: Diagnostic Hardware Repair. Telephone: 1-800-551-1957.

Service Contracts

For information about service contracts call: 1-800-552-3248.

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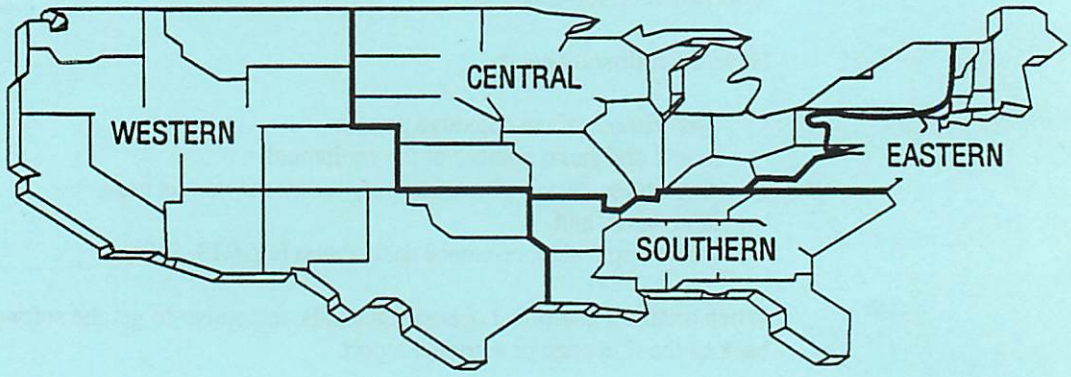

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Excluded from this warranty are expendable supply items such as, but not limited to, electrodes, batteries, magnetic media, leadwires, patient cables, ink, and ribbons.

This warranty does not cover repairs or replacement parts which, in the opinion of MARQUETTE, are required as the result of abuse or misuse of the equipment, failure to maintain the equipment in the manner described in any applicable instructions, use of electrodes, batteries, magnetic media, or other supplies not recommended by MARQUETTE, or faulty devices connected to MARQUETTE equipment.

THIS WARRANTY IS GIVEN BY MARQUETTE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY AS TO MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

Michael J Endich

PRESIDENT

Printed in USA

A0058B

User's Comments

Your comments and suggestions will help us in our continuous effort to improve the quality and usefulness of our manual. Please take a minute to fill out this survey and return it to us. Check (✓) only one box for each question. Thank you.

	Very Good	Good	Fair	Poor
What is your overall rating of this manual?	☐	☐	☐	☐
How would you rate the organization of the entire manual?	☐	☐	☐	☐
How would you rate the arrangement of information/illustrations on each page?	☐	☐	☐	☐
How would you rate the accuracy of the information?	☐	☐	☐	☐
How would you rate the completeness of the information?	☐	☐	☐	☐
How would you rate the readability of the text?	☐	☐	☐	☐
How would you rate the manual's overall usability?	☐	☐	☐	☐

How often have you used this manual? ☐ Very often ☐ Very little

When did you use It? ☐ Calibration ☐ Maintenance ☐ Repair

(Service manuals only–Check all that apply) ☐ Other _____

Was anything missing that should be added? ☐ Yes ☐ No

If yes, describe _____

How can this manual be improved? _____

_____

_____

Any additional comments? _____

_____

_____

Please list your job title _____

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Revision History

Page revision letters tell you which pages changed with the most current release of the manual.

This page is here to help you keep track of the revision level of each page in this manual. This may be important if you have two separate updates to the manual and don't know which one is the most current.

Most pages start at revision A.

Most of the pages in this manual start at revision A. The next time the manual changes, all pages that were changed go to revision B. The next time the manual changes, all changed pages go to revision C. (Notice that some pages will go straight from revision A to revision C, because they were not changed by revision B.)

If you have more than one update and don't know which page is the most current, all you have to do is look at the page revision letter at the bottom of the page. The latest letter in the alphabet is the most current page. (Be sure you have the same manual number though. If one manual number replaces another, the revision starts at A again, but the edition keeps on increasing.)

Revision Summary

Edition	Revision	Manual #	Date	Comment
1st	none	000-9478-003	26 Nov 1985	Initial release of the MAC PC Service manual.
2nd	none	000-9478-003	25 Feb 1985	Update to manual.
3rd	none	000-9478-003	2 April 1986	Update to manual.
4th	none	000-9478-003	16 April 1986	Update to manual.
5th	none	000-9478-003	24 April 1986	Update to manual.
6th	none	000-9478-003	16 May 1986	Update to manual.
7th	none	000-9478-003	17 Sept 1986	Update to manual.
8th	none	000-9478-003	28 Sept 1988	Update to manual.
9th	none	000-9478-003	23 Nov 1988	Update to manual.
10th	none	000-9478-003	1 Feb 1989	Update to manual.
11th	none	000-9478-003	15 Aug 1989	Update to manual.
12th	none	000-9478-003	2 April 1990	Update to manual.
13th	A	407098-001	12 Sept 1991	MAC PC Field Service Manual replaced MAC PC Service manual.
14th	B	407098-001	4 Dec 1991	Pinout descriptions for input and output connectors, theory of operation, and AM-4 acquisition module information added to general troubleshooting.
15th	C	407098-001	9 March 1992	Changes to Preventive Maintenance Inspection Report and Equipment Safety Tests added. Format changes made throughout.

Contents

Quick Reference

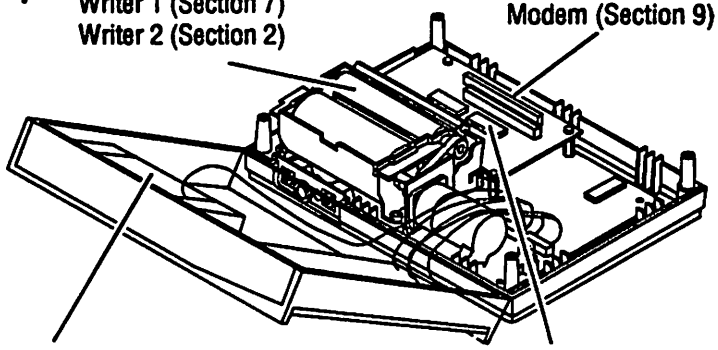
Schematic diagrams and parts lists for pcb assemblies are contained in the MAC PC Parts Reference Manual, manual number 407099-001.

Parts lists for the MAC PC electrocardiograph and power modules are in section 10, Parts Lists and Drawings.

General Troubleshooting (Section 4)

Writer 1 (Section 7)
Writer 2 (Section 2)

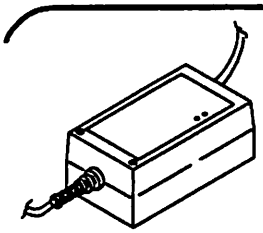
Modem (Section 9)



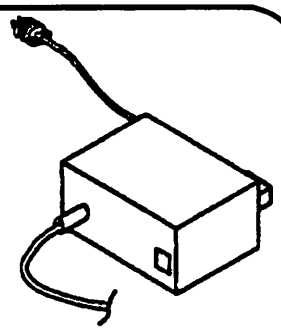
Battery Replacement
(See Maintenance, Section 3)

Software
(See General Troubleshooting, Section 4)

Power Modules (Section 5)

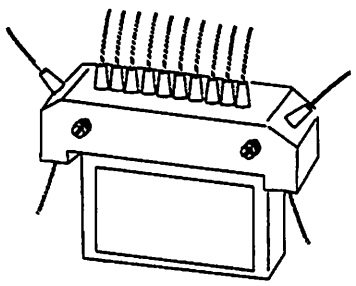


PM-2 Power Module

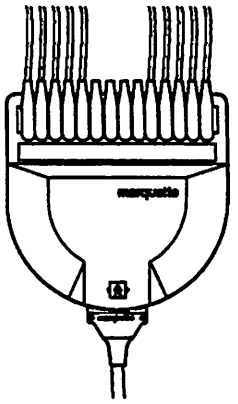


PM-3 Power Module

Acquisition Modules (See ECG Circuits, Section 6)



AM-3 Acquisition Module



AM-4 Acquisition Module

1 Introduction

2 General Information

Contents

3 Maintenance

4 General Troubleshooting

4 General Troubleshooting (Cont)

Contents

4 General Troubleshooting (Cont)

5 Power Module

6 ECG Circuits

7 Writer 1

8 Writer 2

9 Modem

Table of Contents

10 Parts Lists and Drawings

This section covers the OMAR drawings for the MAC PC electrocardiograph which began at about March of 1988. The MAC PC electrocardiograph drawings that occurred before this time can be found in another manual, the MAC PC Parts Reference Manual, pn 407099-001. Note that all of the MAC PC electrocardiograph drawings can be found in the parts reference manual. Also, the "Commonly Replaced Parts" list found in this section provides many of the more commonly used pre-OMAR part numbers.

10 Parts Lists and Drawings (Cont)

Contents

11 Tech Memo Summary

Chapter 1
Introduction

Manual Content

Introduction

This field service manual has been prepared by the Diagnostic Technical Communications staff of Marquette Electronics, Inc. It is intended for service representatives and technical personnel involved in the servicing of assemblies in the MAC PC electrocardiograph.

This manual includes information necessary for troubleshooting the equipment.

Chapter Content

The information in this manual is organized into 11 chapters. The content of these 11 chapters is summarized briefly below.

Introduction — Chapter 1, Introduction, includes the manual and chapter content, safety warnings and cautions, equipment symbols, and notes on how to use this manual.

General Information — Chapter 2, General Information, includes the equipment description, technical characteristics, and other general information.

Maintenance — Chapter 3, Maintenance, provides maintenance information on the MAC PC electrocardiograph. Also included in this chapter is information on controlling electrostatic discharge damage.

General Troubleshooting — Chapter 4, General Troubleshooting, contains some general troubleshooting information from an overall perspective. This chapter also directs the user to one of the following chapters which further cover the various assemblies of the MAC PC electrocardiograph.

Power Module — Chapter 5, Power Module, provides specific maintenance and troubleshooting information for the power modules which are used to charge the Nicad batteries in the unit.

ECG Circuits — Chapter 6, ECG Circuits, addresses problems with ECG data acquisition and the quality of ECG data as it appears in the thermal paper.

Writer 1 — Chapter 7, Writer 1, includes specific maintenance and troubleshooting information on the original writer used in the electrocardiograph.

Writer 2 — Chapter 8, Writer 2, contains specific maintenance and troubleshooting information on the current writer used in the unit.

Modem — Chapter 9, Modem, describes the operation of the modem. Troubleshooting information for the modem is also included.

Manual Content (Cont)

Chapter Content (Cont)

Parts Lists and Drawings

Chapter 10, Parts Lists and Drawings, contains all of the upper-level parts lists and drawings for use in repairing the MAC PC electrocardiograph down to the assembly level. The parts lists and schematic diagrams for all pcb assemblies in the unit are contained in the parts reference manual. (See "Related Manuals" in this chapter for details.)

Tech Memo Summary

Chapter 11, Tech Memo Summary, provides a summary of the tech memos written for the unit by the Marquette Electronics, Inc service department. These memos provide valuable information about the unit from a service and maintenance point of view.

Safety

Responsibility of Manufacturer

Marquette Electronics, Inc is responsible for the effects on safety, reliability, and performance only if,

- assembly operations, extensions, readjustments, modifications, or repairs are carried out by persons authorized by Marquette,
- the electrical installation of the relevant room complies with the requirements of the appropriate regulations, and
- the MAC PC electrocardiograph is used in accordance with the instructions for use.

General

This equipment is protected against the effects of cardiac defibrillator discharge to ensure recovery, as required by test standards.

This equipment will not cause abnormal operation of the patient's cardiac pacemaker or other electrical stimulator.

This device uses a computerized ECG analysis program which can be used as a tool in ECG tracing interpretation. This computerized interpretation is only significant when used in conjunction with clinical findings. All computer-generated tracings should be overread by a qualified physician.

To ensure patient safety, use only parts and accessories manufactured or recommended by Marquette Electronics, Inc.

Contact Marquette Electronics for information before connecting any devices to this equipment that are not mentioned in this manual.

Failure on the part of the responsible individual, hospital, or institution using this equipment to implement a satisfactory maintenance schedule may cause undue equipment failure and possible health hazards.

Safety (Cont)

Warnings

⚠ DANGER

Possible explosion hazard. Do NOT use in the presence of flammable anesthetics.

M15287-1A

⚠ WARNING

For continued protection against fire hazard, replace only with the same type and rating of fuse.

M15287-2A

⚠ WARNING

Ensure that the conductive parts of lead electrodes and associated connectors do not contact other conductive parts, including earth. Otherwise, injury to the patient may occur.

M15287-4A

⚠ WARNING

To ensure defibrillator protection and protection against high-frequency burns, use only the AM-2, AM-3, or AM-4 with this equipment.

M15287-6B

⚠ WARNING

The interconnection of auxiliary equipment with this device may increase the total leakage current. This may result in excessive leakage current as established by the applicable standards.

M15287-7A

Safety (Cont)

Warnings (Cont)

⚠WARNING

The total system chassis risk current must not exceed 100 microamperes.
Otherwise, serious injury or death could result.

M15287-9B

⚠WARNING

Do NOT come into contact with the unit while a patient is being defibrillated. Otherwise, serious injury or death could result.

M15287-8A

⚠WARNING

Disconnect the patient from the unit BEFORE connecting a personal computer to the unit. Otherwise, the patient could be injured.

M15287-12A

⚠WARNING

Operate the unit from its battery if the integrity of the protective earth conductor arrangement is in doubt. Otherwise, the patient could be injured.

M15287-14A

⚠CAUTION

Keep fingers clear of the paper roller because the roller could pinch your fingers.

M15287-15A

Safety (Cont)

Warnings (Cont)

⚠CAUTION

To reduce the risk of electric shock, do NOT remove cover (or back). Refer servicing to qualified personnel.

M15287-16A

⚠CAUTION

Federal law restricts this device to sale by or on the order of a physician.

M15287-17A

Equipment Symbols

Type B equipment. Type B equipment is suitable for intentional external and internal application to the patient, excluding direct conductive connection to the patients' heart.

Type BF equipment. Type BF equipment is suitable for intentional external and internal application to the patient, excluding direct cardiac application. Type BF equipment is type B equipment with an F-type isolated (floating) applied part. The paddles indicate that the device is defibrillator proof.

Equipotential (this is ground lug).

This equipment complies with part 68 FCC rules. The FCC registration number is AM995H-67836-DT-E and the ringer equivalence is 1.4B.

When this symbol appears on a leadwire, it indicates that the leadwire is resistive.

In units equipped with the analog output option, this symbol means that you should consult the appropriate chapter of the manual before connecting any equipment to the A/O or RS232 connectors.

A/O is the analog output connector.

RS232 is the RS232 connector.

AM is the acquisition module connector.

PM is the power module connector.

AUX is the auxiliary connector which is used in "local" transmissions.

AC/DC converter, rectifier, substitute power supply. Use a Marquette Electronics power module.

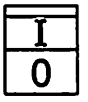
is the symbol for alternating current.

Equipment Symbols (Cont)

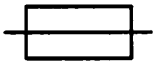
⚠CAUTION

To reduce the risk of electric shock, do NOT remove cover (or back). Refer servicing to qualified personnel.

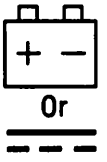
M15287-16A



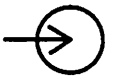
Mains power switch. The "I" is the on position and the "0" is the off position.



This is the symbol for a fuse.



Indicates direct current. On the Power Module-2 (PM-2) when the LED next to this symbol is on, this means that the MAC PC electrocardiogrph is charging.

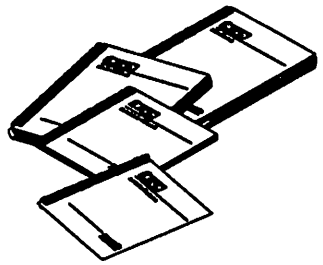


Input.

Output.

Class II equipment.

Related Manuals



This list contains additional documents covering the MAC PC electrocardiograph.

Operator

PN 000-9478-001	MAC PC Operator's Guide (software version 1.04)
PN 000-9478-006	MAC PC Operator's Guide (software version 004A and 004B)
PN 000-9478-014	MAC PC Operator's Guide (software version 005B)
PN 000-9591-001	MAC PC Operator's Guide (software version 005C and 105C)
PN 403506-001	MAC PC Operator's Guide (software version 006A, 106A, 007A, 007B, 107A, 008A, 108A)
PN 404522-001	MAC PC CAPOC Operator's Manual (software version 006A, 106A)
PN 000-9478-021	MAC PC Instruction Sheet (software version 004A and 004B)
PN 000-9591-002	MAC PC Instruction Sheet (software version 005C and 105C)
PN 403507-001	MAC PC Instruction Sheet (software version 006A, 106A, 007A, 007B, 107A, 008A, 108A)
PN 000-90160-010	Physicians Guide to Marquette Electronics Resting ECG Analysis (all versions)
PN 402675-001	MAC PC Transmitting Guide (software version 005C and 105C)
PN 403508-001	MAC PC Transmitting Guide (software version 006A, 106A, 007A, 007B, 107A, 008A, 108A)

Service

PN 407098-001	MAC PC Field Service Manual
PN 407099-001	MAC PC Parts Reference Manual
PN 403732-001	MAC PC Battery Maintenance
PN 000-9488-002	AM-3 Supplement
PN 406141-001	AM-4 Field Service Manual
PN 407250-001	AM-4 Parts Reference Manual

Service Requirements

Refer servicing for equipment under warranty to Marquette Electronics authorized service personnel. Any attempt to repair equipment under warranty will void that warranty.

It is the responsibility of users requiring service to report the need for service to Marquette Electronics or to one of their authorized agents.

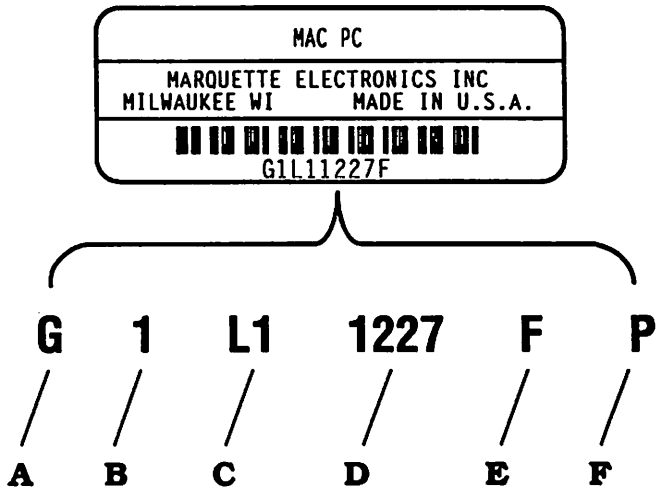
Failure on the part of the responsible individual, hospital, or institution using this equipment to implement a satisfactory maintenance schedule may cause undue equipment failure and possible health hazard.

Equipment Identification

Each MAC PC electrocardiograph is identified by a unique serial number.

Each MAC PC electrocardiograph is identified by a unique serial number. This number is located on a label placed on the back panel of each unit. A serial number contains from 9 to 11 characters.

The product code for MAC PC electrocardiograph is L1. A sample serial number is shown below.



A	month manufactured	A = January B = February C = March D = April E = May F = June G = July H = August J = September K = October L = November M = December
B	year manufactured	1 = 1991 2 = 1992 3 = 1993 and so on
C	product code	L1 = MAC PC electrocardiograph
D	product sequential number	In this case, this is the 1227th MAC PC electrocardiograph
E	division	F = Diagnostic G = Monitoring
F	additional description	These last 2 characters may describe alterations to the standard product, refurbished equipment, etc. P = prototype not conforming to marketing specification R = refurbished equipment

FCC Requirements

Type of Service

Your MAC PC electrocardiograph is designed to be used on standard device telephone lines. Connection to telephone company-provided coin service (central office implemented systems) is prohibited. Connection to party lines service is subject to state tariffs.

Telephone Company Procedures

The goal of the telephone company is to provide you the best service it can. In order to do this, it may occasionally be necessary for them to make changes in their equipment, operations, or procedures. If these changes might affect your service or the operation of your equipment, the telephone company will give you notice, in writing, to allow you to make any changes necessary to maintain uninterrupted service.

If you have any questions about your telephone line, such as how many pieces of equipment you can connect to it, the telephone company will provide this information upon request.

In certain circumstances, it may be necessary for the telephone company to request information from you concerning the equipment which you have connected to your telephone line. Upon request of the telephone company, provide the FCC registration number and the ringer equivalence number (REN) of the equipment which is connected to your line; both of these items are listed on the equipment label. The sum of all of the RENs on your telephone lines should be less than 5 in order to assure proper service from your telephone company. In some cases, a sum of 5 may not be usable on a given line.

If Problems Arise

If any of your telephone equipment is not operating properly, you should immediately remove it from your telephone line, as it may cause harm to the telephone network. If the telephone company notes a problem, they may temporarily discontinue service. When practical, they will notify you in advance of this disconnection. If advance notice is not feasible, you will be notified as soon as possible. When you are notified, you will be given the opportunity to correct the problem and informed of your right to file a complaint with the FCC.

NOTE

This equipment complies with part 68 FCC rules. The FCC registration number is AM995H-67836-DT-E and the ringer equivalence is 1.4B.

Abbreviations

Listed below are the abbreviations and miscellaneous symbols used in this manual.

A1–A4	auxiliary leads
AM-1	acquisition module-1
AM-1M	acquisition module-1 modified
AM-2	acquisition module-2
AM-3	acquisition module-3
AM-4	acquisition module-4
A	ampere
AAMI	American Association of Medical Instrumentation
ABP	ambulatory blood pressure
AC, ac	alternating current
A/D	analog-to-digital
Adj	adjustable
AG	automotive glass
AHA	American Heart Association
Al	aluminium
AllSec	all sector
AllTrk	all track
ALT	alternate
Alt-Off	alternate offset
AM, am	ante meridiem
amp	ampere
Ampl	amplifier
AMU	ambulatory monitoring unit
ANLG	analog
AnsrTone	answer tone
ASCII	American Standard Code for Information Interchange
ASSY	assembly
Attn	attention
AUST	Australian
AUSTRALN	Australian
AUX	auxiliary
aVF	augmented left leg lead
avg	average
aVL	augmented left arm lead
aVR	augmented right arm lead
AWG	American Wire Gage
Bd	board, baud
BDGH	binding head
BKSP	backspace
BLK	black
BLU	blue
BPM	beats per minute
BRN	brown
BSI	British Standards Institute
Btu	British thermal unit
CAPOC	Computer Assisted Practice of Cardiology
CASE	Computer Aided System for Exercise
Cer	ceramic
CFM	cubic feet/minute
CGR	computer graphic record
CH	channel
cm	centimeter
Cmd	command number
CMOS	complementary metal-oxide semiconductor
COM1	communications port 1
COM2	communications port 2
ComLink	communications link
Comp	composition
CONT, Cont	Continental, continued
CPU	central processing unit
CR	diode
CRC	cyclic redundancy check
CRD	cord
CRT, crt	cathode ray tube
CTRL	control
CSA	Canadian Standards Association
DA	damping relay
DAC, dac	digital-to-analog converter
dB, db	decibel
dBm	decibel (referenced to 1 milliwatt into 600 ohms)
DC, dc	direct current
DD	double density
DDD	Digital Diagnostic Diskette
DEC	Digital Equipment Corporation
Del	delete
DEMO	demonstration
DES	designation
DevId	device identification
Diag	diagnostic
DIP	dual in-line package
Dirctry	directory
DOB	date of birth
DOS	disk operating system
DP	diametral pitch
DPST	double-pole, single-throw
DRAM	dynamic RAM
DR/DT	digital recording/digital transmission
DSKTP	desktop

Abbreviations (Cont)

E	enable, vector electrode site
ECG	electrocardiogram
ECO	Engineering Change Order
EEPROM	electrically erasable programmable ROM
eg	for example
EGA	enhanced graphics adapter
EMF	electromotive force
EMI	electromagnetic interference
ENG	English
EOF	end of file
EPIC	Electronic Patient Information Chart
EPLD	electrically programmable logic device
EPROM	eraseable, programmable, read-only memory
ESD	electrostatic discharge
etc	et cetera
EURO	European
EXP	Expanded
F1–F5	function keys 1 through 5
F	fuse, Farad
Fax	facisimile
FCC	Federal Communications Commission
FE	front end
FILH	fillister head
FLH	flat head
FLRAM	flash RAM
FR	French
FrntEnd	front end
FSK	frequency shift keying
ft	foot, feet
g	gram
GB	Great Britain
GERM	German
GND	ground
GRN	green
GRY	gray
H	high, vector electrode site
HDLC	high-level data link control
HEX, Hex	hexagon
HiRes	high-resolution
Hr	hour
Hz	hertz
I	on, input, vector electrode site
I, II, III	limb leads
IC	integrated circuit
ID	identification
ie	that is
IEC	International Electrotechnical Commission
IT	Italian
in	inch
IN	input
INC, Inc, inc	incorporated
Info	information
Ins	insert
I/O	input/output
ISA	industry standard architecture
JIS	Japan Industrial Standards
K	kilo, kilobyte, kilohm, 1000, 1024
kg	kilogram
kHz	kilohertz
kV	kilovolt
Kyb	keyboard
L1	level one
L2	level two
L	line
LA	left arm
lb	pound
LCD	liquid crystal display
Lcl Line	local line
Ld Grps	lead groups
LED	light-emitting diode
LH	left hand
LL	left leg
LocPc	Local MAC PC
LogRetry	log retry
m	meter
M	megabyte, metric, vector electrode site
MAC	Microcomputer Augmented Cardiograph

Abbreviations (Cont)

MAC PC	Microcomputer Augmented Cardiograph Personal Cardiograph
max	maximum
MEI	Marquette Electronics, Inc
MEM	memory
MF	metal film
MHz	megahertz
min	minimum
Misc	miscellaneous
mm	millimeter
MOD	modem
Modem	modulator-demodulator
MOS	metal oxide semiconductor
MPE	metallized polycarbonate expitaxial
ms	milliseconds
MS-DOS	Microsoft-Disk Operating System
mtg	mounting
MTR	MOTOR
MUSE	Marquette Universal System for Electrocardiography
mux	multiplexer
mV	millivolt
N	neutral
NA	not applicable
NC	no connection
NLQ	near letter quality
NMOS	N-channel metal-oxide semiconductor
NO	normally open
No	number
norm	normal
O	off, original
OE	other errors
OH	off-hook relay
OneSec	one sector
ORG	orange
OUT	output
oz	ounce
P	P wave (section of the ECG waveform)
Params	parameters
PatData	patient data
PatInfo	patient information
PATN	patient
PC	personal computer
PC	printed circuit
PCB, pcb	printed circuit board
Pgm	program
PgmId	program identification
PID	patient identification digit
PLCC	plastic leadless chip carrier
PM, pm	post meridiem, preventive maintenance
PN, pn	part number
PNH	pan head
p-p	peak-to-peak
Pro-Off	progressive offset
PSK	phase shift keying
PWR	power
PWR CRD	power cord
Q	transistor
QA	quality assurance
QAD	Quality Assurance Deviation
QAM	quadrature amplitude modulation (phase and amplitude modulation)
QC	quality control
QRS	QRS complex (portion of ECG waveform)
QTY	quantity
R	resistor, red, reset
RA	right angle
RA	right arm
RAM	random-access memory
RC	resistor capacitor
Ref	reference, refresh
REV	revision
rf	radio frequency
rfi	radio frequency interference
RGB	red, green, blue
RI	ring indicate
RL	right leg
ROM	read only memory
rpt	report
RTN	return
RVS	reverse
R/W	read/write
12SL	12 simultaneous leads
S, s	second, select, switch
SB	slow-blow
SCL	Safe Current Limits

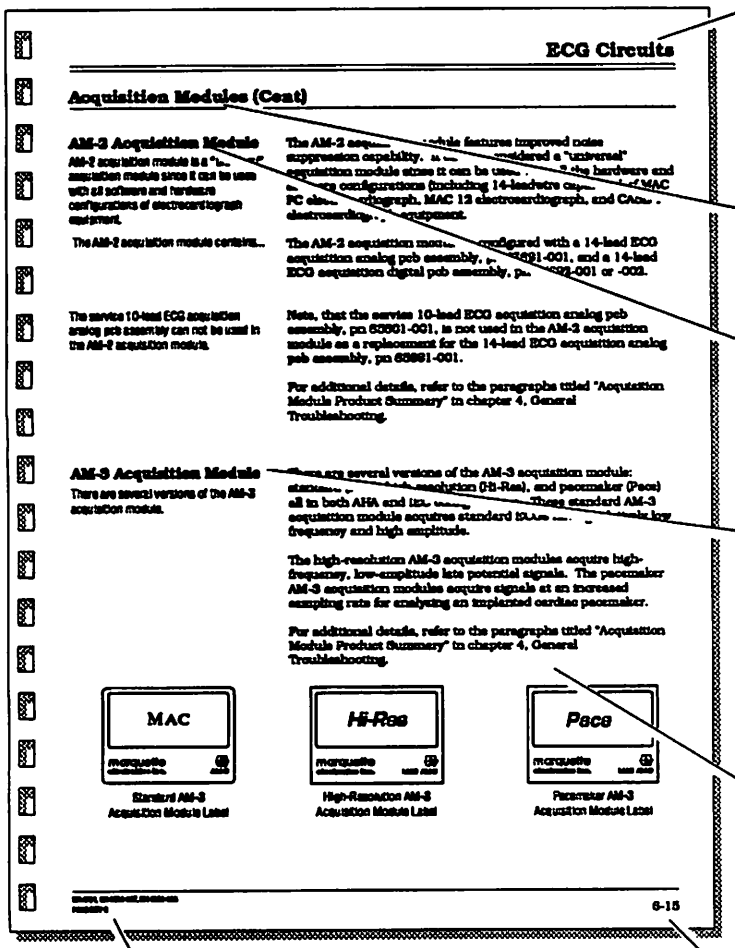
Abbreviations (Cont)

SD	schematic diagram
SE	serial input/output errors
sec	second
SEER	Solid-state Electronic ECG Recorder
SER	Serbo
SERB	Serbo
Serbo	Serbo-Croatian language
SING	Singapore
SP	Spanish
SPDT	single-pole, double-throw
SRAM	static RAM
ST-T	ST-T wave (section of the ECG waveform)
standrd	standard
STD	standard
stmts	statements
SVT	power cord type: 300 V
SW	Swedish
SW, sw	switch
Tant	tantalum
TE	timeout errors
Tech	technical
TM	trademark
Tot	total number or errors
TP	test point
TRAM	Transport Remote Acquisition Monitor
TTL	transistor-transistor logic
TVS	transient voltage suppressor
UE	undefined errors
uF	microfarad
UL	Underwriters' Laboratory, Inc
Unconf	unconfirmed
UUT	unit-under-test
V1–V6	precordial leads
V123	V1, V2, V3
V3R	precordial lead
V456	V4, V5, V6
V4R	precordial lead
V	volt, volts
VA	volt-amperes
Var	variable
Vdc	voltage, direct current
VGA	video graphics array
VIA	versatile interface adapter
VIO	violet
Volt	voltage
VRAM	video RAM
W	watt
w/	with
WHT	white
WI	Wisconsin
x	by (as in "8-1/2 x 11")
XYZ	orthogonal leads
Y	year, yellow
yr	year
yrs	years
YY	year

List of Symbols

µF	microfarad
µs, µsec	microsecond
68K	68000
&	and
#	number
°C	degrees Celsius
°F	degrees Fahrenheit
Ω	Ohm, ohm
%	percent
®	registered
*	The use of an asterisk after a signal name (eg, ADLC* or R/W*) indicates that the signal or portion of a multifunction signal is active at its relatively lower potential, or "active-low". (Signals without the asterisk suffix are active at their relatively higher potential, or "active-high".)

Using This Manual



The top line of the page displays the name of the chapter you are in. Use these large chapter titles to find the area you want quickly. The chapter number will appear on this line on the first page of every chapter.

On most pages, there is another title below the chapter title that further details the information appearing on the page.

Most pages are split into 2 columns. The left column is meant to be scanned quickly so that you can narrow your search to a specific topic of interest.

The left column also contains 2 more headings. These are shown in bold type, and further define information appearing on the page. The left column also includes small graphics and comments that summarize information in the right column.

The right column elaborates on the information provided in the left column. This is where you will find instructions, background information, and step-by-step procedures.

The page number on each page shows the number of the chapter, followed by the number of the page in that chapter.

A revision letter has been assigned to each page in this manual. It is found in the lower inside corner of the page. As pages are changed, they receive the next letter in the alphabet. This is especially important if you have 2 different revisions of the same page and don't know which one is more current. Page revisions correspond to the Revision History found near the beginning of the manual.

While we tried to get this manual published with the fewest errors and best information possible, we might have missed something. If you find an error or have a suggestion on things that should be added, please contact Diagnostic Technical Communications with your ideas. We appreciate your comments.

Contact us at:

Diagnostic Technical Communications
Marquette Electronics, Inc
8700 West Tower Avenue
Milwaukee, WI 53223
1-800-551-1957

Chapter 2
General Information

Introduction

Purpose of Equipment

The MAC PC electrocardiograph provides portable ECG acquisition and full electrocardiographic analysis. A fully-charged unit can analyze and record up to 50 ECGs without recharging, permitting a physician to obtain an ECG anywhere. Internal memory stores up to 15 ECGs. Reports and waveforms can be printed by a 4-inch thermal writer. Printer output format options include 4 groups of 3 leads and 3-channel, real-time rhythm records.

Description of Equipment

The MAC PC electrocardiograph is about the size of a medical textbook, and is packaged with an external power module and acquisition module. The power module can be plugged into a suitable power outlet to charge the unit. The acquisition module obtains the raw ECG data from the patient and transmits buffered, filtered, and digitized data to the MAC PC electrocardiograph.

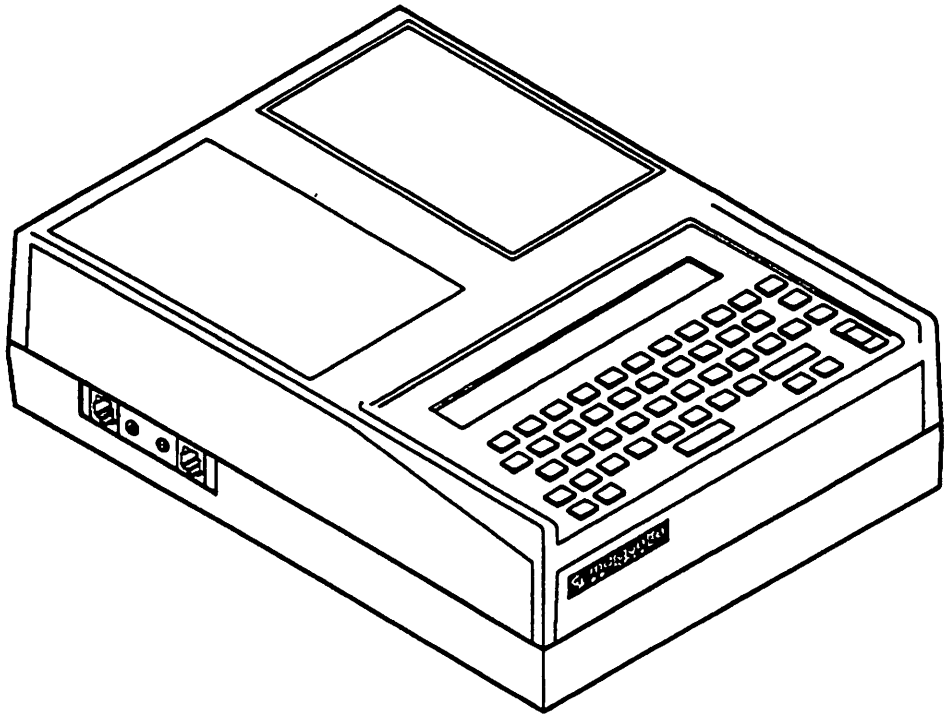


Figure 2-1. MAC PC Electrocardiograph.

Technical Characteristics and Information

Instrument Type	3- or 6- channel microcomputer-augmented automatic electrocardiograph
Paper Type	Thermal sensitive, fully gridded, 4-1/4 in by 75 ft (roll)
Recording Technique	Computer-controlled digital dot array (12.5 μV resolution at standard gain)
Switching Technique	Automatic/manual instantaneous with optimal trace positioning
Standard Leads Available	I, II, III, aVR, aVL, aVF, V1, V2, V3, V4, V5, and V6
Optional Formats	Various channels and lead configuration, user selectable 2- through 6-channel formats Digital data acquisition module with replaceable leadwires and telephone type cable
Frequency Response	0.01-109 Hz with 5 mm amplitude signal
Writer Speed	5, 10, 25, and 50 mm/s, microprocessor controlled
Input Impedance	100 Megaohms, defibrillator-protected
Patient Leakage Current	<10 μA (meets AAMI standards SCL 1278)
Chassis Leakage Current	<100 μA (meets AAMI standards SCL 1278)
Common Mode Rejection	130 dB minimum, up to 180 dB with digital processing which also rejects signal mode (inductive) ac interference
Sensitivity	2.5, 5, 10, and 20 mm/mV
Input Dynamic Range	20 mV
Electrode Offset Tolerance	320 mV dc
Input Channels	Simultaneous acquisition of all classical leads
A/D Resolution	12 bits
Digital Sampling Rate	2000 samples per second per channel
Special Microprocessor Functions	Arm lead reversal detection Optimal trace positioning Lead-off and/or artifact detection Sensitivity detection Drift reduction AC interference rejection

Technical Characteristics and Information (Cont)

Power Module AC Requirements	9518-001: 120 V, 0.33 A, 60 Hz 9518-002: 240 V, 0.20 A, 50 Hz 9518-003: 100 V, 0.33 A, 50 Hz 9518-005: 200 V, 0.20 A, 50 Hz 9577-001: 120 V, 1.0 A, 50/60 Hz 9577-002: 220 V, 0.40 A, 50 Hz 9577-003: 240 V, 0.40 A, 50/60 Hz 9577-004: 100 V, 1.0 A, 50/60 Hz
DC Power	Self-contained batteries with sufficient power for up to 50 ECGs Recharge time: 12-14 hour typical from full discharge Comes with ac power module
Overall Weight	5 kg (11 lb) approximate
Dimensions	Height: 8.89 cm (3.5 in) Width: 21.97 cm (6.65 in) Depth: 30.48 cm (12 in)
Processor PCB Assembly Fuse	F1: 1 A, 125 V, axial-lead
Power Supply Fuse	9577-001: 1 A, 250 V, in-line 9577-002: 1/2 A, 250 V, in-line 9577-003: 1/2 A, 250 V, in-line 9577-004: 1 A, 250 V, in-line
RS232 Communication Link	Data bits: 8, not programmable Parity: Off, not programmable Stop bits: 1 or 2, user-programmable Baud rate: 75, 150, 300, 1200, 4800, 9600, 19.2 K, user-programmable Range: 9.16 m (30 ft) maximum Protocol: Xmodem (128 byte packets, checksum, receiver initiated) ECG transmission: Transmit only (cannot receive ECGs), asynchronous, full duplex, 3-wire (TxD, RxD, Gnd)
Transmission Time (typical)	Compressed: 8 seconds Uncompressed: 90 seconds

Special Tools and Items Needed

A "standard" set of tools and test equipment are needed.

A standard set of tools and test equipment are needed such as hand tools, oscilloscope, and DVOM. These "standard tools" are not listed but are vital to have as a service person while working on the unit.

The following items are also needed to service the unit:

- 1,1,1 trichloroethane—available as Carbo Chlor, Dr. Scat, or other brands (buy locally), and
- leakage tester.

Preparation For Use

The following information will help to prepare the MAC PC electrocardiograph for use.

Connector Identification

The following connector information applies to the MAC PC electrocardiograph. The modem and analog output are both options for the MAC PC electrocardiograph. The unit can have either a modem or analog output, but not both.

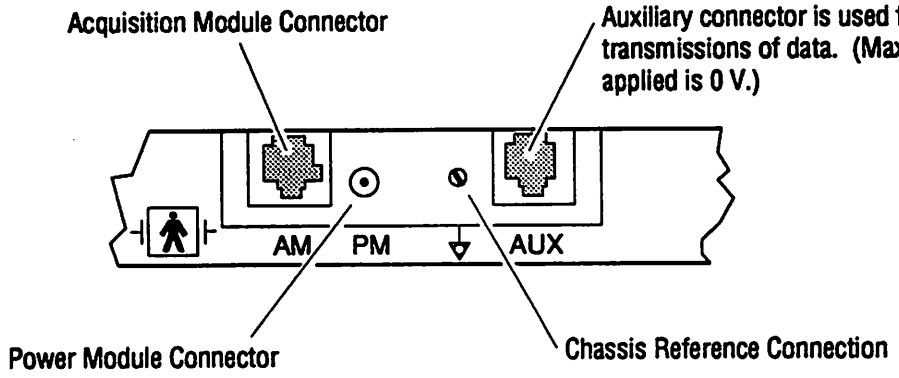


Figure 2-2. Side Panel Connectors

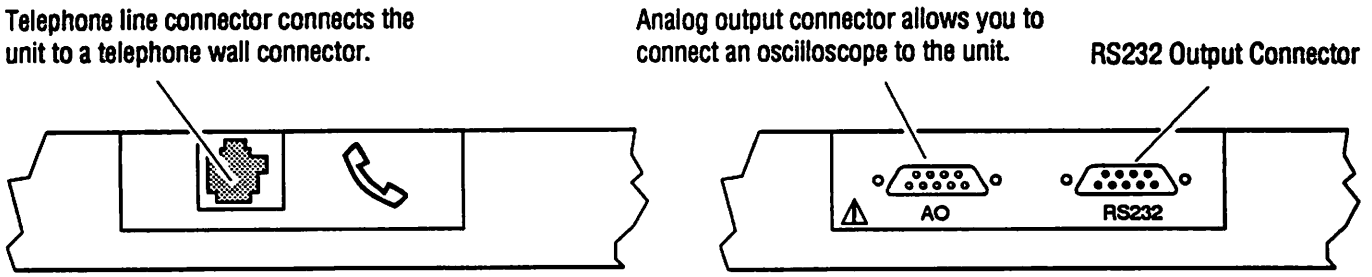
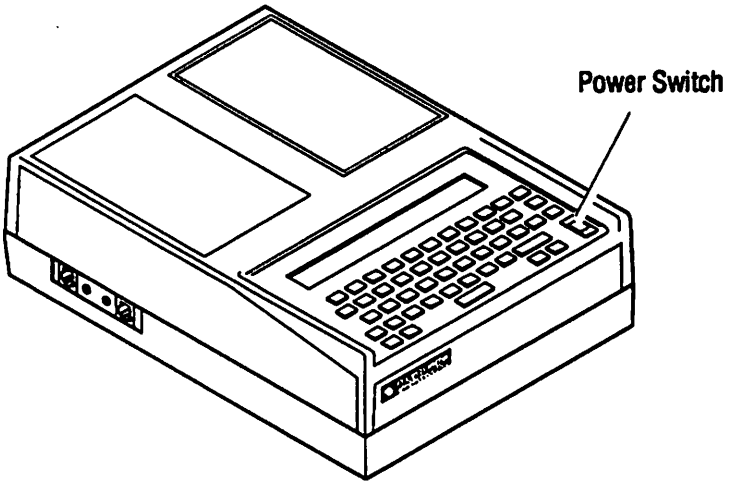


Figure 2-3. Back Panel Connectors

Preparation For Use (Cont)

Electrical Preparation

1. Apply power to the unit by pressing the power switch.



2. A message similar to the following will appear briefly. (For a full explanation of this message, refer to the paragraphs titled "Battery Charging" in this chapter.)

Number of ECGs that can be taken before the battery should be charged.

Maximum number of ECGs that can be taken on a fully charged battery.

```
BATTERY IS 37/50
OK                                NOT CHARGING
```

3. Next a message similar to this is displayed.

The "XXXX" stands for the installed software version.

```
MAC-PC Pgm XXXX SELF TEST 12
```

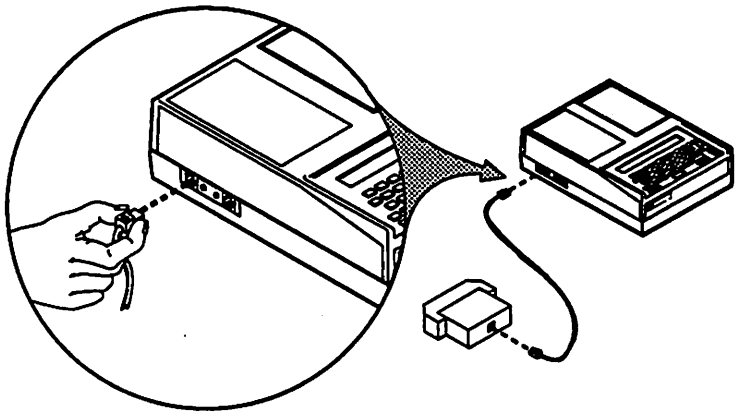
4. Finally, the Main Menu will appear.

```
Task   V1+II+V5
PatInfo   Rhythm   25 mm/s   10 mm/mV   More
```

Preparation For Use (Cont)

Electrical Preparation (Cont)

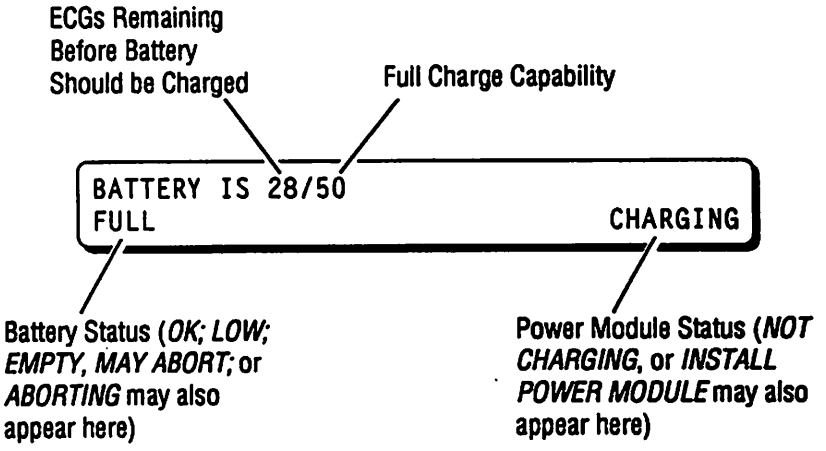
5. Connect the telephone-type connector end of the acquisition module to the connector on the side of the unit.



Battery Information

Your MAC PC electrocardiograph provides a "fuel gauge" that indicates how much charge remains in the battery. This gauge is displayed whenever you:

- press the power switch to turn the unit either on or off, or
- press and hold the power switch. The gauge will remain on the display as long as the power switch is held down.



Preparation For Use (Cont)

Battery Information (Cont)

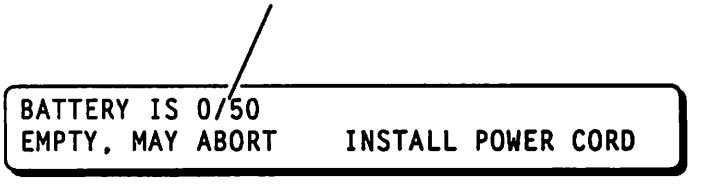
The fuel gauge shows the following.

ECGs Remaining This tells you how many standard ECGs may be taken before the battery should be charged. A "standard ECG" is defined as the acquisition and printout of a two-page RMR format report. If you use longer report formats or you record rhythm to verify electrode placement, you'll get fewer ECGs from a fully charged battery.

Full Charge Capability This tells you how many standard ECGs may be taken with a fully charged battery.

Battery Status When the "0/50" lcd display appears or when the unit "beeps" 4 times in a row, the MAC PC electrocardiograph should be charged continuously for at least 14 hours. Failure to do so may cause permanent damage to the battery. The unit is fully charged when "*50/50*" appears on the lcd display.

The "*0/50*" indicates that it is time to charge the battery.



Besides the gauge numbers, the battery status messages tell you at a glance how your battery is doing. Based on the battery's current state of charge, you may see any of the following messages.

FULL The battery is fully charged.

OK The battery is between *FULL* and *LOW*.

LOW The battery contains enough energy for at least 1 to 5 more ECGs.

EMPTY, MAY ABORT The battery is very low. If you decide to continue using your MAC PC electrocardiograph, it may abort.

Preparation For Use (Cont)

Battery Information (Cont)

ABORTING The battery is too low to continue the current operation you were performing so the unit has turned itself off.

At this point you have 2 options.

1. Stop using the MAC PC electrocardiograph and charge the unit as described at the start of this chapter. This is the recommended approach.

2. Attempt a different operation. Even though the MAC PC electrocardiograph has aborted from one operation, it may allow you to perform a different operation. Press the power switch to restart the unit and try another operation. However, this is the least recommended option as power to the MAC PC electrocardiograph has become critically low.

The power module status messages are shown in the lower right corner of the display.

CHARGING The battery is charging normally.

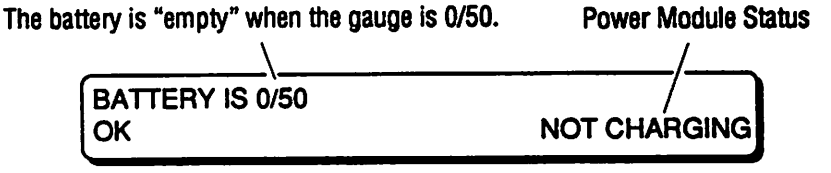
NOT CHARGING The battery is not charging because the power module is not plugged in or has temporarily turned itself off.

INSTALL POWER MODULE The battery is low or empty and charging is recommended.

Preparation For Use (Cont)

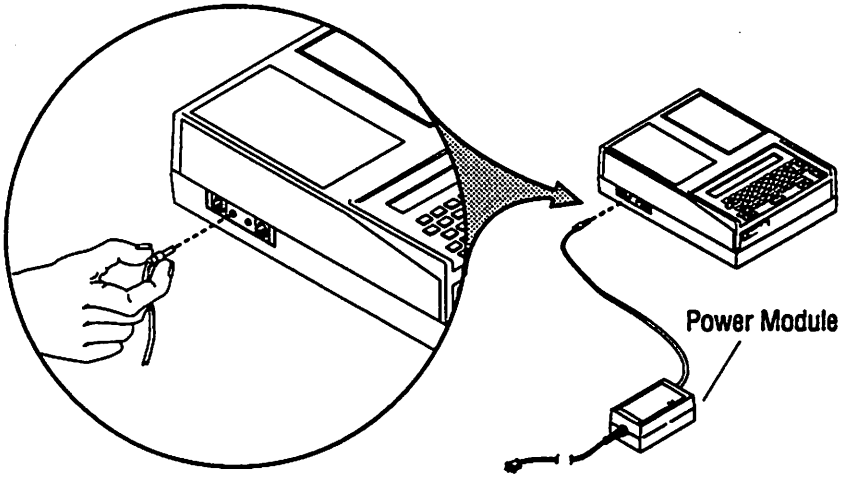
Battery Charging

Use a power module to charge the battery when the lcd "fuel gauge" indicates that the battery is empty.

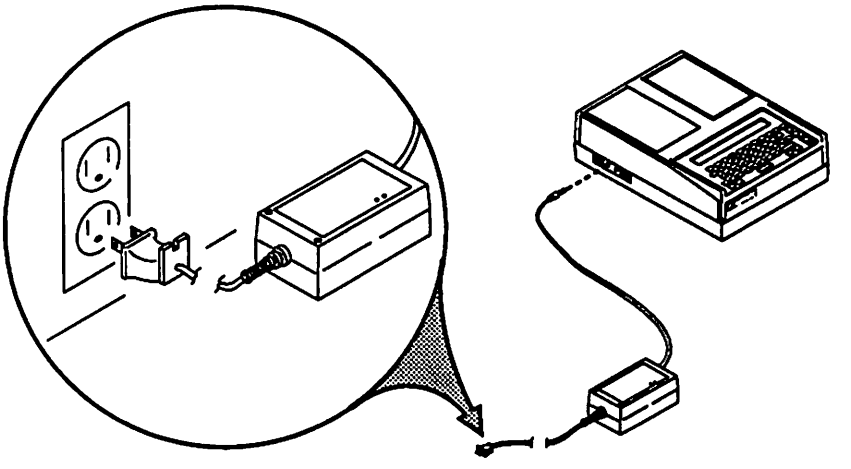


The MAC PC electrocardiograph may be charged with either the Power Module-2 or Power Module-3. To charge the unit follow these steps.

1. Verify that the power module is off [the mains power switch is in the off (0) position]. Connect the power module cable to the connector (labelled PM) located on the side of the unit.



2. Connect the power module cable to a typical ac wall outlet. (Power Module-3 must be connected to a grounded outlet.) Next, press the "1" part of the mains power switch on the power module to turn on the power module.



Preparation For Use (Cont)

Using a Power Module

The MAC PC electrocardiograph can be used while it is connected to a power module. Also, a power module can remain connected to the MAC PC electrocardiograph continuously without harming the unit. The MAC PC electrocardiograph may be charged with either the Power Module-2 or Power Module-3.

Power Module

Power Module-2 has 2 LED indicators on the unit.

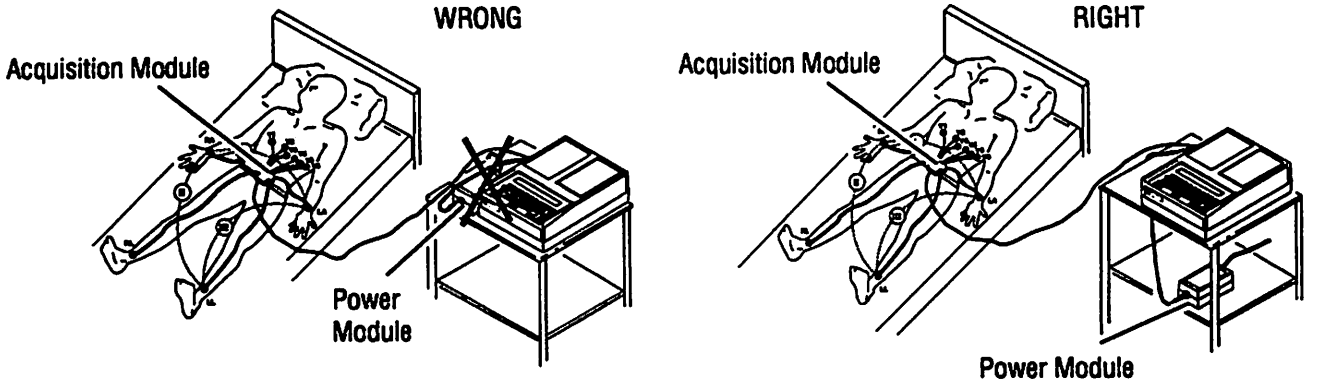
- When the "LINE" LED is on, this indicates that the power module is plugged into a wall outlet.
- When the LED next to the battery symbol is lit, this indicates that the MAC PC electrocardiograph is charging.
- If this LED is not lit, then make sure the power module is properly attached to the unit. If it is, and the LED remains off, then contact Marquette Service.

Electrocardiograph Setup

If you have selected *none(ac)* timeout, make sure that the MAC PC electrocardiograph is turned off while it is charging. For more information, see the operator's manual. (See "Related Manuals" in chapter 1, Introduction.) When the unit is turned off, nothing is visible on the lcd display.

Power Module Placement

To avoid line frequency noise when you are recording an ECG, place the power module away from the patient leadwires and the acquisition module.



Automatic Shutdown

- If you operate the power module in a very warm area or run a long (several minutes) rhythm strip, the power module may turn itself off to cool down.
- This is not true for Power Module-3. This is normal and will not affect the unit's operation, as long as your battery is charged.

Operation

Introduction

The MAC PC electrocardiograph uses menus to control its operation, similar to other electrocardiographs.

The MAC PC electrocardiograph is a very adaptable ECG machine. It allows a user to configure several options to "customize" it for the user's particular application.

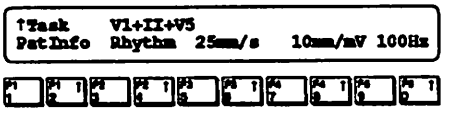
Powering up the unit

The first step in operating the MAC PC electrocardiograph is to power it up and get the Main Menu displayed. With the unit being battery powered this may require more than just pressing a switch. The state of the battery can affect whether the MAC PC electrocardiograph powers up or not.

Close attention must be paid to the battery status (charge level). For details, see the paragraphs titled "Battery Maintenance" in chapter 3, Maintenance. It covers some of the symptoms that a MAC PC electrocardiograph may experience as the result of a battery problem.

Once the powerup selftest is completed, the Main Menu is displayed.

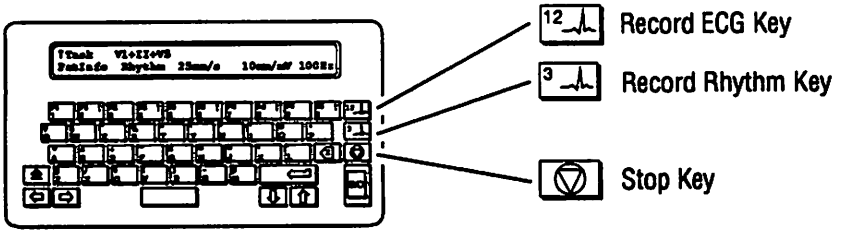
When power is applied to the unit, it performs a powerup selftest. This test checks a variety of parameters and when done (successfully) the Main Menu is displayed on the lcd.



If the powerup selftest detects a fault, it stops and generates a display which indirectly describes the detected problem. (For details, see the paragraphs titled "Powerup Selftest" in chapter 4, General Troubleshooting.)

The 2 MAC PC electrocardiograph operating modes are record ECG and record rhythm.

The MAC PC electrocardiograph operates in 2 primary modes, record ECG and record rhythm. Both modes are much more fully described in the operator's manual. (For details, see "Related Manuals" in chapter 1, Introduction.)



Hardware Diagnostics Menu

To access the Hardware Diagnostics Menu

starting from the Main Menu,

press [⇧] and [F1 2] to reach the System Functions Menu.

Then press [F3 5] or [F3 6] to display the Hardware Diagnostics Menu options

The Hardware Diagnostics Menu includes 8 built-in diagnostic tests which are described below.

Hardware Diagnostics Menu options

- *Writer* performs 2 tests on the writer assembly that check speed, thermal print head, and capstan/roller.
- *Memory* offers 2 tests that can detect stuck RAM bits or bad RAM devices.
- *FrntEnd* includes diagnostics for the acquisition module.
- *Modem* offers a checkout test for the modem pcb assembly. The modem is an option.
- *Pcard* is a loopback diagnostic test for the AUX connector. Before running this test, verify that the front end connector (acquisition module) is working properly. Connect the connectors labelled AUX and AM with a straight cable, pn 5516-005.

  Run the test. The value displayed after *Total:* will change rapidly. No numbers (errors) should be displayed after *E1*, *E2*, *E3*, or *E3*.
- *Keyboard* displays the version of software in EPROM U8 (the keyboard controller).
- *Analog* is used to generate a series of triangle and square waveforms by the analog output option.
- *RS232* is a loopback diagnostic test for the RS232 option.

Manufacturing Menu

Start with the MAC PC electrocardiograph turned off. The manufacturing menu is accessed by pressing down the F1 1 and F5 0 keys,

then briefly pressing the power switch key.

The Manufacturing Menu contains a series of utilities used during manufacturing and for general maintenance/calibration. Note that not all of the utilities are used in the field, therefore they are not described here.

Remember that many functions of the MAC PC electrocardiograph are controlled by software. Parameters relating to the motor and the thermal print head voltage, among others, are stored in memory and can be changed. Changing one of these parameters, however, can have a serious effect on the MAC PC electrocardiograph (such as burning out the thermal print head). You should be very careful when using these utilities so that the unit is not damaged by mistake.

Next a password display is shown,

```
ENTER PASSWORD
PGM 83350-006A
```

enter MACPC, and press ⏎ to get the Manufacturing Menu.

To access the Manufacturing Menu, press down the F1-1 and F5-0 keys, then briefly press the power switch. A password display should be shown on the lcd. After entering MACPC and pressing the ⏎ key, the Manufacturing Menu is displayed.

```
MfgSecAdjEngSavLodBrnResMotSboBatChgEnd
```

The Manufacturing Menu consists of a series of three-letter codes across the top line of the lcd. To select a utility from the menu enter its code and press ⏎.

Numbers appearing on the lcd are ($) hexadecimal values.

The next few pages further describe those utilities from this menu that might be useful in the field. Numbers appearing on the lcd are ($) hexadecimal values.

Note, that in the password display there is a part number on the second line. This number describes the keyboard software used in U8.

Mfg

The *Mfg* selection contains several utilities used for calibration.

```
SET DEFAULTS ?    YES
 YES      NO
```

When you enter *Mfg* and press ⏎, a default display is shown first. To use the default values for calibrating the unit, enter *YES* by pressing the function key below it and ⏎. It is not recommended that *NO* be entered in response to this question.

```
HEAD VOLTAGE 15.5
PRESS <CR> TO ACCEPT. STOPKEY TO QUIT
```

After *YES* is selected, the next display concerns the head voltage. If the thermal print head voltage is not to be changed, press the ⊘ key.

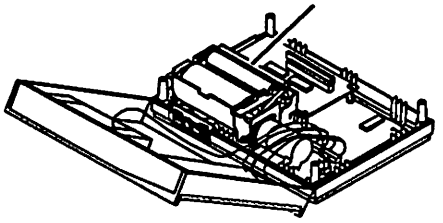
Manufacturing Menu (Cont)

Mfg (Cont)

Adjusting the thermal print head voltage

Remember that the thermal print head voltage is software controlled, you can adjust it with this procedure. Before changing the thermal print head voltage, you should read the value written on the thermal print head in the unit. Each thermal print head has a different voltage for optimum printing and thermal print head life.

Thermal Print Head Label



```
HEAD VOLTAGE 15.5
PRESS <CR> TO ACCEPT. STOPKEY TO QUIT
```

Enter the value you read off the thermal print head. The value (1) in the tens column can not be changed. When done, press the [⏎] key. This starts the writer calibration utility.

Writer Calibration

```
Writer Calibration
PRESS <CR> TO CONTINUE
```

The next utility is for internal writer speed calibration. To start the utility, press [⏎]. The writer starts its internal calibration with a thermal paper speed of 25 mm/s, then 10 mm/s, and finally at 5 mm/s.

Note, that during this internal writer calibration, no mechanical adjustments are necessary.

```
Configuration complete
Press any key to continue
```

When the calibration is done, another message is displayed stating that the configuration is complete. Press any key to return to the Manufacturing Menu.

Hed

```
          THERMAL HEAD SETTINGS
VOLTAGE  STROBE   QUIT
```

This utility is used for adjusting the thermal print head voltage. A choice is given to adjust the thermal print head voltage or the width of the strobe pulses. Do not change the strobe pulses.

The thermal print head voltage adjustment is the same as the thermal print head voltage adjustment display shown as part of the *Mfg* selection. Adjusting the thermal print head voltage is performed exactly the same way.

Once the thermal print head voltage is entered, the menu is repeated. Press the F3-5 or F3-6 keys to quit and return to the Manufacturing Menu.

Manufacturing Menu (Cont)

Adj This utility is commonly used in the writer adjustment procedure. It displays the amount of current supplied to the dc motor as a hexadecimal value. Remember that the microprocessor must "see" an acceptable motor current in order to accurately detect out of paper and door open conditions in the writer assembly.

```
ADJUST WRITER TO CHANGE MOTOR CURRENT
MEASURED VALUE = 57 ps01 vs01 sv9D
```

Before using this utility, make sure there is thermal paper in the writer assembly. To start the utility enter *Adj*. The thermal paper will start running through the writer assembly at 25 mm/s, but nothing is printed on it.

The display shows several values. Only the first one (just after the = sign) is relevant since it is the measured motor current. For Writer 1 and Writer 2 the number should range between $40 and $90.

The dc motor current is affected by the amount of thermal print head pressure.

To stop the thermal paper, press the [▽] key.

For more information on using this utility, refer to "Writer 1 Adjustments" in chapter 7, Writer 1, and "Writer 2 Adjustments" in chapter 8, Writer 2.

Eng This utility is used to change power values for several devices inside and used with the unit. These values should not be changed in the field unless otherwise instructed.

Sav This utility saves any configuration entries in the memory.

Lcd This utility is used for checking out the lcd. It offers several display options that write the preprogrammed character set to the lcd. It also has a test that can be used to check the keyboard keys.

Note, if the unit is running and you have reached the Manufacturing Menu, you already know that the lcd and keyboard are okay. (For details, see the paragraphs titled "Powerup Selftest" in chapter 4, General Troubleshooting.)

Brn This utility should not be used.

Res This utility should not be used.

Manufacturing Menu (Cont)

Mot

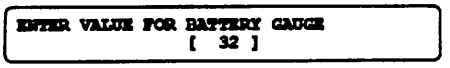
This utility is used in writer calibration. It is used to start the internal writer calibration, which was described under the *Mfg* selection, and to change the current limits for sensing paper out at the different thermal paper speeds. More information is presented on this utility in the paragraphs titled "Writer 1 Adjustments" in chapter 7, Writer 1, and "Writer 2 Adjustments" in chapter 8, Writer 2.

Sho

This utility is used to display the contents of memory locations. It is sometimes used when the thermal print head is replaced.

Press the [▽] key to return to the Manufacturing Menu.

Bat



This utility is used to change the battery charge gauge. When the battery is disconnected from the circuit boards, the gauge is set to zero. Using this utility you can reprogram the battery gauge to its value before the battery was disconnected.

Chg

This utility temporarily enables or disables the power module (charger).

End

Typing *End* exits the Manufacturing Menu.

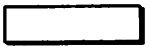
Functions of Keys on the Keyboard

F1-1 through F5-0 function keys are used to select items displayed on the lcd immediately above the keys. The function keys are labeled in groups of 2, ie F1-1 and F1-2. Pressing either the 1 or 2 key is the same as pressing the F1 key.

ENTER key. After entering data, it is usually necessary to press this key so that the unit's microprocessor will accept the completed entry. This key is referred to as <CR> on the lcd.

SHIFT key. This key is used in conjunction with other keys to type shifted characters (such as capital letters) or to access special functions.

DELETE key. Pressing this key causes the last character before the cursor to be deleted from the lcd display.



SPACE BAR key. Pressing this key enters a space in the data being input.

LEFT and RIGHT ARROW keys. These keys can be used to move the cursor around on the lcd display.

The left arrow key has a dual function. If the Main Menu is displayed, pressing the left arrow key causes the thermal paper to advance for a brief time.

UP and DOWN ARROW keys. If the Main Menu is displayed, pressing either of these keys changes the lcd display contrast (increases or decreases brightness, respectively).

RECORD ECG key. Pressing this key causes the MAC PC electrocardiograph to acquire 10 seconds of data, analyze it, and print out the specified reports.

RECORD RHYTHM key. Pressing this key causes the MAC PC electrocardiograph to acquire and print either a 3- or 6-lead report.

POWER SWITCH. Pressing this switch the first time powers up the unit. Pressing it a second time powers off the unit. This key is sometimes referred to as *on/off* on the lcd.

PAPER ADVANCE keys. The Z key has a dual function. You can use it to enter the letter 'z'. If the Main Menu is displayed, pressing it and the shift key simultaneously causes the thermal paper to advance for 7.5 seconds.

STOP key. When this key is pressed, whatever function that was running is stopped, any reports that were printing are stopped, and the Main Menu is displayed again.

Using the Master Password

To access the Setup Menu, you must enter either the level 1 password or the master algorithm.

The Setup Menu is used to program many functions important in the operation of the unit. To enter the Setup Menu you must enter the level 1 password or else know how to use the master algorithm. Once you have entered the Setup Menu, you can reprogram the passwords.

L1 and L2 are the factory-programmed passwords.

The level 1 and level 2 passwords are programmed as L1 and L2 at the factory. Try these first, since many users never change them.

If the setup information has been lost (eg the battery has discharged too far), it will have to be reprogrammed. Access the Setup Menu using the master algorithm.

Using the master algorithm to generate a password number

The master algorithm involves a bit of calculation, so it helps to have a pencil and paper handy.

When the password prompt appears, enter the letters **MEIMAC**. A six-digit number is then displayed, for example 044689. Before entering the new password, this number must be deleted. Press the delete key 6 times. Note, even though it has been deleted, the original number will remain on the lcd.

1st and 3rd
2nd and 4th
3rd and 5th
4th and 6th
5th and 1st
6th and 2nd

To generate the new number, add the digits of the displayed number in the following way: first and third digits, second and fourth digits, third and fifth digits, fourth and sixth digits, fifth and first digits, and the sixth and second digits. When adding the digits, disregard the 10s column. For the number 044689, the new number is 402583.

Enter the new number and press [⏎]. The Setup Menu should then be displayed.

Chapter 3
Maintenance

Maintenance

Introduction

Failure to implement a satisfactory maintenance schedule may cause undue equipment failure and possible health hazards.

Failure to implement a satisfactory maintenance schedule may cause undue equipment failure and possible health hazards. Unless an Equipment Maintenance Contract exists, Marquette Electronics does not in any manner assume the responsibility for performing the recommended maintenance procedures. The sole responsibility rests with the individual or institution using the equipment. Marquette Electronics service personnel may, at their discretion, use this procedure as a helpful guide during visits to the equipment site.

This chapter contains several recommended maintenance procedures for the MAC PC electrocardiograph. A preventive maintenance inspection report and a log that can be used to record the various maintenance and repair procedures done on the unit during its life begin the chapter. An illustrated guide to opening and closing the unit for service is provided next.

The remainder of this chapter includes:

- comprehensive information on maintaining the battery, including procedures for checking the amount of charge left in the battery, how to charge, replace, and store the battery,
- a visual inspection procedure which looks for "obvious" problems, such things as disconnected cables, poor repairs, missing hardware,
- guidelines for thermal paper storage to insure that the printed ECG images will be retained for 3–5 years,
- recommendations for regular cleaning of the outside and inside of the unit, including the thermal print head in the writer, and
- information on equipment safety tests (leakage current tests) which should be performed every 6 months or whenever the unit is opened for maintenance or repair work.
- Before performing any maintenance or repair on the unit, protection against harmful effects of electrostatic discharge must be taken. (For details, see paragraphs titled "Controlling Electrostatic Discharge Damage" in this chapter.)

Controlling Electrostatic Discharge Damage

The equipment makes extensive use of CMOS components. CMOS components are used because they are more safe from noise and consume less power than standard TTL or NMOS components. However, CMOS components are more easily damaged by electrostatic discharge (ESD) damage than other semiconductors.

ESD damage, usually a subtle weakening of semiconductor junctions, can range from corruption of digital memory to catastrophic failure, making a component or a number of components permanently unusable. Although it is more common for CMOS components to fail from ESD damage, *no semiconductor device is completely safe from ESD damage.*

The inputs and outputs of all of the equipment components are protected from ESD damage, so they are no more susceptible to ESD damage during normal operation than any other device. However, when the equipment components are being serviced, the components are exposed to several sources of static electricity, ranging from human hands to improperly grounded test equipment. For this reason, it is recommended that all service workstations be as static-free as possible.

Although these guidelines cannot ensure a 100% ESD-free workstation, they will help reduce the sources of ESD damage.

The following guidelines can help make your workstation more resistant to the damage that can be caused by static electricity.

- Discharge any static charge you may have built up before handling semiconductors or assemblies containing semiconductors.
- A grounded, antistatic wristband or heelstrap should be worn at all times when repairing assemblies containing semiconductors.
- Use only properly grounded soldering and test equipment.
- Use a static-free surface when working on assemblies containing semiconductors.
- Do not remove semiconductors or assemblies containing semiconductors from antistatic containers (bags) until needed.
- Make sure power to an assembly is turned off before removing or inserting a semiconductor.
- Do not slide semiconductors or assemblies containing semiconductors across any surface.
- Do not touch semiconductor leads unless absolutely necessary.
- Semiconductors and assemblies containing semiconductors should be stored only in antistatic bags or boxes.

Preventive Maintenance Inspection Report

Introduction

These maintenance guidelines should be followed to prevent unnecessary equipment/supply failure and/or possible health hazard.

These maintenance guidelines should be followed to prevent unnecessary equipment/supply failure and/or possible health hazard.

Every 6 months carry out routine maintenance/performance checks.

Every 6 months the following routine maintenance/performance checks should be performed on the unit. A maintenance/repair log is included in this chapter to aid in keeping a record of the work done on the unit. The diagnostic tests are the easiest way to verify performance. (For details, see "Hardware Diagnostics Menu" in chapter 2, General Information.)

A preventive maintenance inspection report is included in this chapter to aid in performing the routine systematically. The specific procedures for carrying out each step are contained in this manual and their location is indicated on the form.

Clean the thermal print head.

To insure the best performance from the thermal writer, clean the thermal print head and queuing sensor regularly. (For detailed instructions, see chapter 8, Writer 2.)

Make sure leakage currents for the electrocardiograph and acquisition module are within allowable limits.

To verify that the unit poses no electrical safety hazards, test the unit's leakage current. (For more information, see the paragraphs titled "Equipment Safety Tests" in this chapter.)

Finally, perform several operational tests to check out overall functioning.

Finally, try performing typical functions. More specifically, try to

- record an ECG, and
- if a modem is installed, transmit and receive ECG data.

These operation tests verify overall functioning.

The preventive maintenance inspection report on the following page can be removed from the manual to make additional copies, if needed.

MAC PC

Preventive Maintenance Inspection Report

DPMMCPC-001B
15 March 1992

(See the Field Service Manual for details.)

Customer _____ Customer Number _____ Date _____

FE _____ FE ID _____ Call Number _____

Equipment Serial Number _____ Software Revision _____

Equipment Options: ____ Modem ____ Analog/Serial Output

Tools Required

- Standard hand tools
- Typewriter platen cleaner (1,1,1 trichloroethane)
- Isopropyl alcohol
- Multimeter
- Leakage current tester (pn MT-1216-01 for 120 V, or equivalent)
- Lint-free cloth (pn TX609)

Visual Inspection

Inspect the following for excess wear and/or any visual signs of damage. (For details, see chapter 3.)

____ Coiled patient cable ____ Correct fuses installed ____ AC power cord ____ Socketed components
____ DC power cord ____ Patient leadwires ____ Cart chassis hardware ____ Internal cables and connectors

Cleaning

(For details, see chapter 3.)

____ Thermal print head ____ Keyboard and display ____ AC power cord
____ Capstan/roller ____ Power supply and fan (PM-3 power module only) ____ DC power cord

Power Supplies

(For details, see chapter 5.)

____ +27 V (±1 V) ____ "Charging" on display
____ Charging current (125–225 mA) ____ Fan OK? (PM-3 power module only)

Diagnostic Tests/Calibration

- Writer (For details, see chapter 7.)
  ____ Roller test ____ Dot test ____ Speed test ____ Thermal paper tracking
  ____ Thermal print head voltage setup ____ MOT (in Manufacturing menu)
- Battery (For details, see chapter 3.)
  ____ Instruct customer on performance of monthly battery deep discharge.

Electrical Safety Tests

(Use for domestic units only. For non-domestic units see DPMAPP-001-4.)

- AC Line Voltage Checkout (For details, see chapter 4.)
  ____ Line to neutral = 120 V
  ____ Line to ground = 120 V
  ____ Neutral to ground <3 V

After the outlet passes the above tests, check the neutral-ground loop resistance. ____ Neutral to ground <2 ohms

- Leakage Test
  Note: Since the MAC PC electrocardiograph, PM-1 power module, and PM-2 power module are double insulated, a leakage test is not required. However, when the MAC PC electrocardiograph is used with the PM-3 power module, which is not double insulated, a leakage test is required.

Note: The following values apply to 120 V ac.	Open		Closed	
	Normal	Reversed	Normal	Reversed
Ground wire leakage to ground (100 µA max)	_____ µA	_____ µA	NA	NA
Chassis leakage to ground (exposed chassis) (100 µA max)	_____ µA	_____ µA	_____ µA	_____ µA
Patient cable leakage to ground (10 µA max)	_____ µA	_____ µA	_____ µA	_____ µA
Patient cable leakage into patient leads from 120 V ac (20 µA max)	NA	NA	_____ µA	_____ µA

- Resistance Measurements
  Ground pin to chassis (PM-3 power module only) _____ <0.1 ohm
  External ground screw to writer chassis (all MAC PC electrocardiographs) _____ <0.1 ohm

Environment

Room temperature _____ (°C/°F) Humidity _____%

Please comment on any other environmental conditions (static, temperature, ac power, etc) that may effect operation or reliability.

Operational Tests

When the power is turned on, the unit should display:

☐ Charger ok

BATTERY IS 50/50 FULL CHARGING

Followed by...

MAC-PC Self Test 123 128K

And finally...

☐ Powerup selftest ok

↑ Task	V1+II+V5			
PatInfo	Rhythm	25 mm/s	10mm/mV	More

Before proceeding, please complete cart setup (including site number and the telephone number of the receiving device if a transmitting unit) as shown in the operator's manual. Also, in Miscellaneous setup, set the "Store/Transmit Control" to Store.

☐ Record rhythm ok

1. Connect an ECG simulator to the patient leads.
2. Press [3]
3. The writer will run a continuous rhythm strip.
4. Press [⊘]

☐ Record ECG ok

☐ Data storage ok

1. Press [12]
2. The display should read "Acquiring Data" for about 10 seconds.
3. The display should then read "ECG Acquisition Complete" followed by "Analyzing ECG".
4. A 12-lead report will be printed and the display will read "Printing Reports".
5. Next, the display will read "Processing ECG".
6. After a successful write to memory, the display will read "ECG Storage Complete".
7. Press "Stop".

The following steps apply only to units with the optional modem.

☐ Transmission ok

1. Press the [⇧] and [F1 1 2] keys simultaneously for the "System Functions" menu.
2. Press the [F1 1 2] key for Storage.
3. Press the [F4 7 8] key for Transmit.
4. Press the [F1 1 2] key for Phone.
5. When the telephone number appears, press [↵].
6. Press the [F1 1 2] key for "No" and then press [↵].
7. When the first patient record appears, press [F1 1 2] for "Yes".
8. The unit will then transmit the selected ECG to a receiving device and display "1 of 1 Transmitted", "Type Any Key to Continue".
9. Press [⊘] to return to the Main Menu.

This completes the operational tests.

This form is to be filed at customer site

Briefly describe all repairs/adjustments made and list all parts replaced. _____

_____

_____

_____

Additional comments: _____

_____

Customer Signature _____ FE Signature _____

Maintenance/Repair Log

SERIAL NUMBER _____

INSTITUTION NAME _____

DATE	MAINTENANCE/REPAIR DONE	BY WHOM (INITIALS)

Maintenance/Repair Log (Cont)

SERIAL NUMBER _____

INSTITUTION NAME _____

DATE	MAINTENANCE/REPAIR DONE	BY WHOM (INITIALS)

Opening the Unit for Service

Introduction

Follow these steps to open and close the unit for service.

Be careful of static!

Be sure to discharge any static charge you may have built up before beginning this procedure. Wear a grounded, anti-static strap. Work on a static-free work surface.

Before you begin

Before you being any repair or mainenance procedure that will involve opening the unit, follow these steps and you will save time later.

> **NOTE**
>
> Whenever the battery cable is disconnected from J9 on the processor pcb assembly, all stored ECG data and setup information is lost.

Whenever the battery cable is to be disconnected, all stored ECGs should be transmitted (if that is what is normally done with the ECG data) and all setup information written down.

With version 006/106 and later software, the setup information can be printed out. Select *"Print"* under Cart Setup. You will have to reenter this information after the service/repair procedure is completed.

```
MAC PC Setup Settings    06-NOV-91 12:56

Phone Numbers
  Number1
    Phone Number 1 Description.....
    Phone Number 1.....
  Number2
    Phone Number 2 Description.....
    Phone Number 2.....
  Number3
    Phone Number 3 Description.....
    Phone Number 3.....
  Number4
    Phone Number 4 Description.....
    Phone Number 4.....

Lead Groups
  Rhythm
    AutoRhythm.....V1, II, V5
    Group1.....I, II, III
    Group2.....aVR, aVL, aVF
    Group3.....V1, V2, V3
    Group4.....V4, V5, V6
```

- Write down the battery gauge value so that you can reprogram it later.

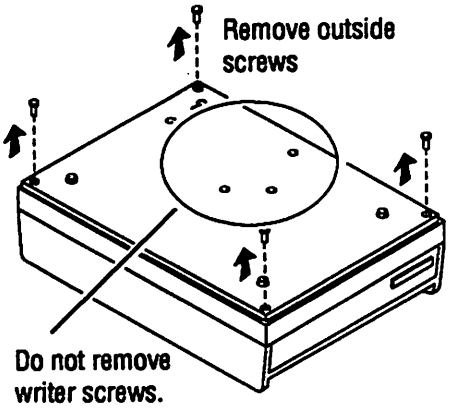
  To display this value, press and hold down the power switch. (When the battery cable is disconnected the gauge is set to 0.)

Use the  switch to remove power from the unit. Turn off and unplug power module, if connected. Unplug any other external connectors, as well.

> **NOTE**
>
> In order to prevent damage to the pcb assemblies, be sure that you are connected to an anti-static strap. Be careful not to bend the pcb assemblies.

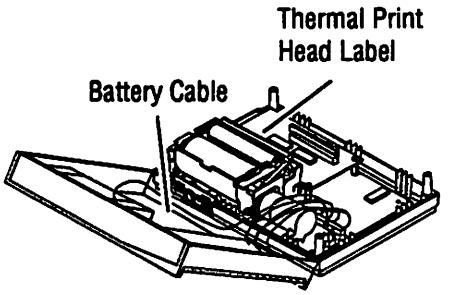
Opening the Unit for Service (Cont)

Basic Disassembly



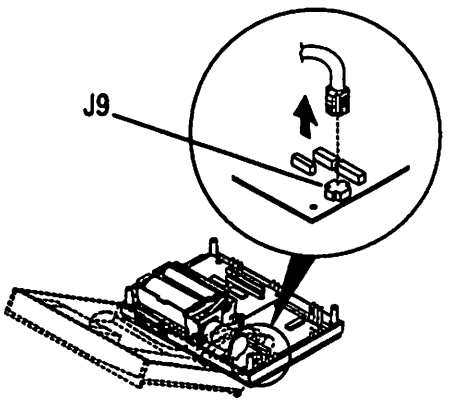
Remember to save and set aside all removed hardware.

Remove the outer screws which hold the 2 halves together. Do not remove the writer screws. Remember to save and set aside all removed hardware.



Lift top half and turn over carefully. The 2 halves of the unit are connected by cabling.

- If you need the thermal print head value, you can see it now. It is written on a label placed on the front of thermal writer casting. (See illustration shown to the left.)



NOTE

You MUST disconnect the battery cable from J9 on the processor pcb assembly first. Failure to do so could cause severe damage to the processor pcb assembly.

- If cables need to be disconnected, the battery cable must be removed from J9 on the processor pcb assembly first before any other cable is disconnected.

  Remember the battery cable is disconnected first and reconnected last.

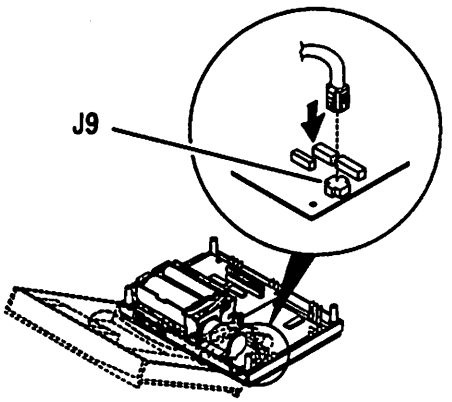
Carry out the maintenance or repair procedure.

Opening the Unit for Service (Cont)

Basic Reassembly

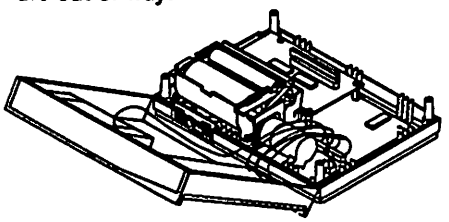
If necessary, connect all cables except the battery cable.

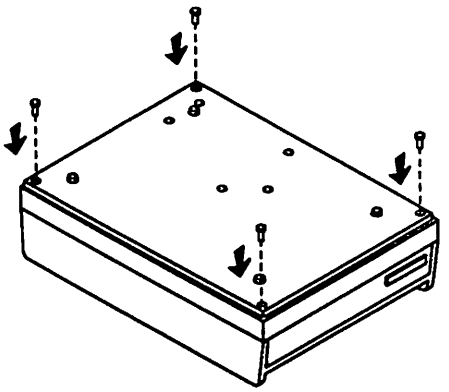
Reconnect the battery cable to J9 on the processor pcb assembly last.



Check that cables are out of way.

Before closing the unit, check to make sure that all cables/ harnesses are tucked out-of-the-way and will not be crimped or pinched when the unit is closed.

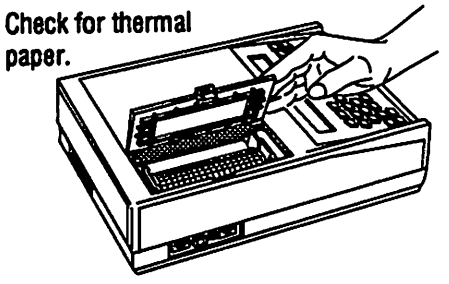




Replace screws in the base.

Opening the Unit for Service (Cont)

Reprogramming the Unit



The final step is to reprogram the MAC PC electrocardiograph with the information you wrote down before beginning the procedure. Make sure there is thermal paper in the thermal writer.

Use the  key to apply power.

```
ENTER PASSWORD
PGM 83350-006A
```

When the lcd message asks for a password, type "MACPC". Press ⏎. This is indicated on the lcd by "<CR>".

```
MfgHedAdjEngSavLodBrnResMotShoBatChgEnd
```

Type "Mfg". Answer "Yes" to *Set Defaults*. Press ⏎.

```
SET DEFAULTS ?     YES
 YES       NO
```

```
HEAD VOLTAGE 15.0
PRESS <CR> TO ACCEPT. STOPKEY TO QUIT
```

Next *HEAD VOLTAGE 1X.X* appears. Confirm that the thermal print head voltage shown on the lcd matches the value that was on the label. If it is correct, press the stop key.

If it is not, enter the correct value. The tens column cannot be changed. Press ⏎.

```
Writer Calibration
PRESS <CR> TO CONTINUE
```

The *Writer Calibration* prompt follows next. Press ⏎. The writer starts its internal calibration with a thermal paper speed of 25 mm/s, then 10 mm/s, and finally at 5 mm/s.

```
Configuration complete
Press any key to continue
```

When the calibration is complete, the message shown to the left is displayed.

```
MfgHedAdjEngSavLodBrnResMotShoBatChgEnd
```

Return to the Manufacturing Menu. Type "Bat". Enter the battery gauge value. Press ⏎.

```
ENTER VALUE FOR BATTERY GAUGE
          [  32 ]
```

Return to the Manufacturing Menu. Type "END". Press ⏎.

```
MAC-PC Pgm 108A Selftest 1
```

Next, the status of the battery is displayed very briefly. This is followed by a selftest. The software version installed in the unit is displayed as part of this test.

```
MAC PC Setup Settings    08-NOV-91 12:58

Phone Numbers
  Number1
    Phone Number 1 Description.....
    Phone Number 1.....
  Number2
    Phone Number 2 Description.....
    Phone Number 2.....
  Number3
    Phone Number 3 Description.....
    Phone Number 3.....
  Number4
    Phone Number 4 Description.....
    Phone Number 4.....

Lead Groups
  Rhythm
    AutoRhythm.....V1, II, V5
    Group1.....I, II, III
    Group2.....aVR, aVL, aVF
    Group3.....V1, V2, V3
    Group4.....V4, V5, V6
```

The final step is to reenter all of the setup values that you wrote down or printed out. You can do this as part of the Cart Setup Menu. (For details, see chapter 2, General Information.)

Battery Maintenance

Introduction

The nickel-cadmium battery in the unit requires simple maintenance.

The battery is an important component that must be maintained regularly. If it is not, then the unit may not work as designed when it is needed most.

Actually, maintaining the battery is simple. It involves monitoring its charge level, making sure the battery is charged when necessary, and once every month performing a deep-discharge/charge cycle. The programs inside the MAC PC electrocardiograph perform several functions for the user which simplify the battery maintenance process.

The following pages describe how to monitor the battery charge level, including the messages that are displayed as the battery is discharged. A short description of the deep-discharge/charge cycle is then provided.

Checking Battery Status

Battery status is displayed upon powerup.

The battery status display is also shown when the power switch is held down.

Momentarily pressing the power switch causes a series of status data to be shown on the lcd. First there is:

- a battery status display, then
- the powerup selftest displays, and finally
- the Main Menu is displayed.

To check further on the battery status or if you miss the display during the powerup sequence, hold down the power switch. This causes the battery status display to be shown on the lcd as long as the power switch is held down. The display indicates the battery charge remaining and whether the battery is being charged.

The message in the lower right states the status of the power module (charger). These messages are described later.

A battery gauge in the top line indicates the number of 2-page ECG reports that may yet be plotted.

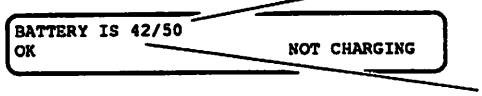
The message in the lower left states the condition of the battery. These messages are described later.

Battery Maintenance (Cont)

Checking Battery Status (Cont)

The battery gauge indicates the number of ECGs that may be acquired and printed.

A fully charged battery can supply enough power for a typical MAC PC electrocardiograph to acquire 50 ECGs, analyze, and then print them. But there are several qualifications regarding the quantity of 50. It is really only a relative number based on typical ECGs. Special report formats, use of the record rhythm function to check ECG signals, even editing the ECG reports can reduce the number of ECGs that can be accomplished on a fully charged battery.



The *50* in the *42/50* value shown in the display to the left indicates that a fully charged battery can typically accomplish 50 ECGs. This value is based on using a 2-page ECG report format.

The *42* in the *42/50* value indicates that there is sufficient power remaining to accomplish (acquire, analyze, and plot) 42 more ECGs that use a 2-page report format.

The battery gauge is only an approximation of the battery capacity remaining.

Keep in mind that the battery gauge really only provides an approximation of the battery power remaining. The power capacity left in a battery depends heavily upon the quality of ECG data and how the unit is used.

As the battery capacity gets low, special messages are displayed.

When the battery gauge reaches *5/50* or less, the display changes to warn the user to connect the power module. If the power module is already connected, then the unit starts to automatically charge the battery. Note, that the MAC PC electrocardiograph is giving the user a warning that it will need to be charged soon. Users should understand that they should not attempt to use all of the power available from the battery. The battery should be recharged at this point!

If the power module is not installed and the battery gauge reaches *5/50* or less, the unit starts to generate an audible warning of 4 brief tones. This is in addition to the battery gauge display. At powerup the 4 tones are generated. They are repeated every 4 minutes until the power module is connected to the unit.

If the power capacity falls to 0/50, the unit may independently power down.

If the battery gauge reaches *0/50*, the unit is essentially out of reserve power. The display changes at this point to indicate that it may abort. The user should stop and immediately connect a power module to the MAC PC electrocardiograph.

The unit measures the available power and compares it against the power required to continue. If there is not enough power left, it may decide to stop processing. It indicates this with the *ABORTING* message. Prior to aborting, the unit generates a series of continuous beeps as a warning. At this point, the only option is to connect a power module. Once the unit has aborted, there is no Main Menu display, it does not operate, and all stored ECG and setup information may be lost.

Battery Maintenance (Cont)

Checking Battery Status (Cont)

Battery Gauge Status Messages

Following is a summary of some of the messages that may appear in the battery gauge display.

Battery Status

FULL	The battery is fully charged.
OK	The battery capacity is less than fully charged but greater than 5/50.
LOW	The battery capacity is sufficient for 1 to 5 more ECGs. The battery should be recharged now.
EMPTY, MAY ABORT	The battery is very low and the unit may abort. The battery should be recharged now!
ABORTING	The MAC PC electrocardiograph is shutting itself off. A series of beeps indicates that the unit is aborting. Remember that essentially everything is lost if the MAC PC electrocardiograph aborts!

Power Module Status

CHARGING	The battery is charging normally.
NOT CHARGING	The battery is not charging, because the power module is not plugged in.
INSTALL POWER MODULE	The power module should be connected to the unit, so the battery can be charged.

Battery Maintenance (Cont)

Periodic Battery Charging

To prolong the life of the battery, it should be cycled through a deep-discharge/charge procedure every month.

Every month the unit battery should be deep discharged and then fully charged.

For the deep-discharge, the power module should be connected. Connecting an acquisition module also speeds up the discharge.

For 006 and later version software, start with the unit turned off. Hold down the D and B keys. Then quickly press down and release the power switch. The display shown to the left should appear.

```
BATTERY DEEP CYCLE
Press any key to continue
```

After pressing any key, the display changes to show the battery status. If an acquisition module is not connected, the display prompts you to connect one. Having the acquisition module connected speeds up the deep-discharge process due to the additional current it requires. Note, that you do not have to connect an acquisition module.

```
BATTERY IS  22/50
INSTALL ACQUISITION MODULE
```

```
BATTERY IS  15/50
PRESS ON/OFF TO STOP
```

The display also flashes a message describing how to stop the deep-discharge process. Press  to interrupt the deep-discharge process if the MAC PC electrocardiograph is needed for a patient.

If a battery seems to discharge rapidly when used, it may need to be cycled through the deep-discharge/charge procedure.

After a short time (or even a few hours depending upon how much the battery was charged), the lcd goes blank. At this point the battery is deep-discharged. The MAC PC electrocardiograph then automatically starts to charge the battery. It should be allowed to charge undisturbed for at least 14 hours. This completes the deep-discharge/charge procedure.

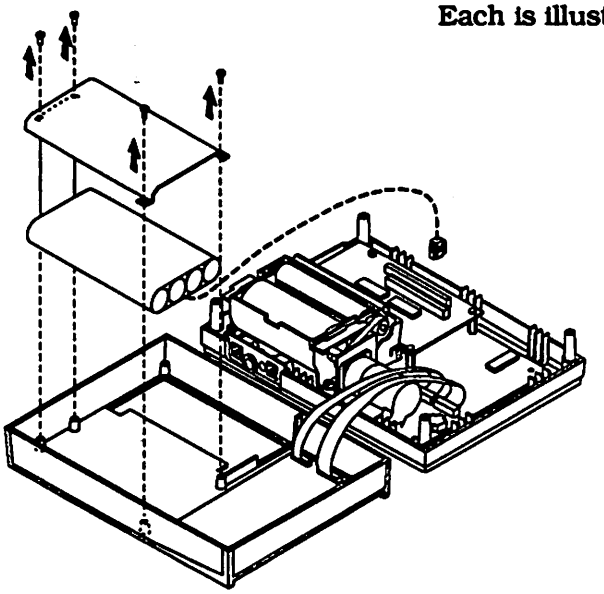
Battery Maintenance (Cont)

Battery Replacement

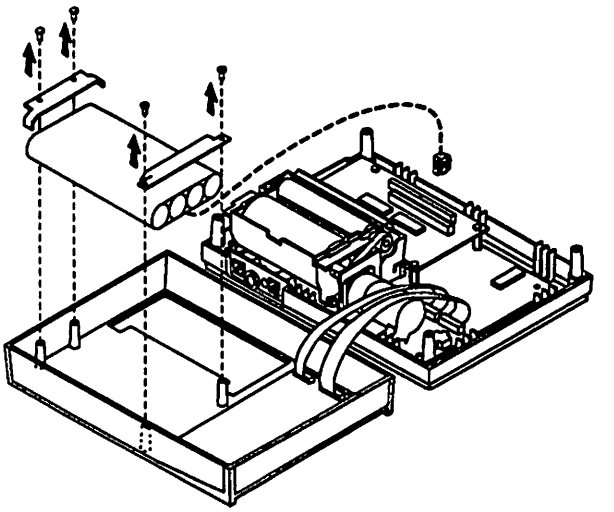
Follow the steps below to replace the battery in the unit. Open the unit for service as described in this chapter.

Remember to save and set aside all removed hardware.

Remove 4 screws from the battery cover. Lift out battery and set aside. Two styles of battery mounting plates have been used. Each is illustrated below.

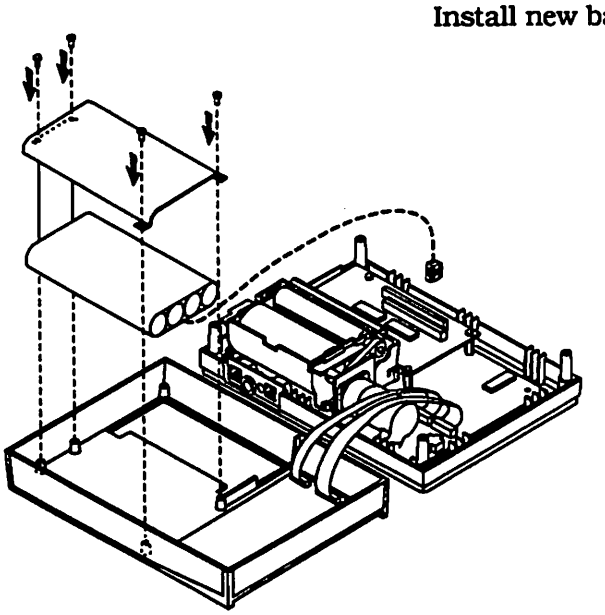


Writer 2

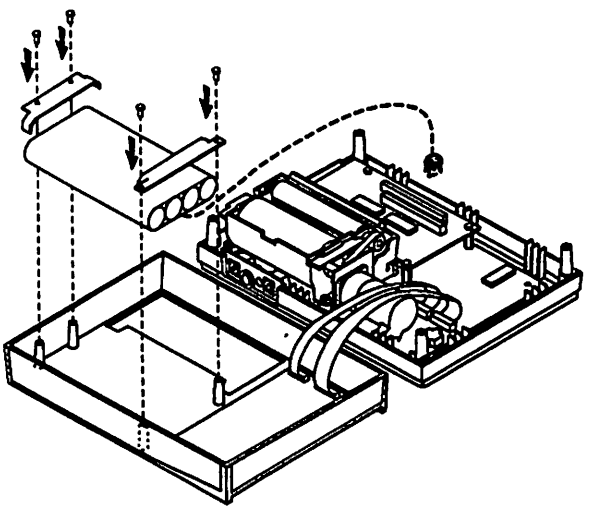


Writer 1

Install new battery. Replace 4 screws in battery cover.



Writer 2



Writer 1

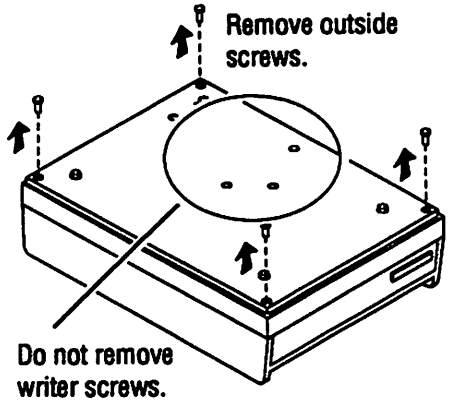
Close the unit as described in the paragraphs titled "Basic Reassembly" in this chapter.

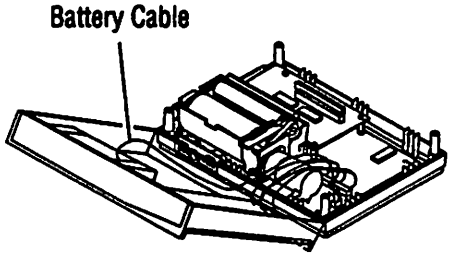
Reprogram the unit. (For details, see paragraphs titled "Reprogramming the Unit" in this chapter.)

Storage Guidelines

If the unit is not used for less than 30 days, no harm will be done to the battery.

If the unit will not be used for longer than 30 days, 2 steps should be taken to protect the battery.





If the unit is unpowered for less than 30 days, no harm will be done to the battery. If the unit will be stored (or remain unpowered) for longer than 30 days, 2 steps should be taken to protect the battery.

First, the battery should be fully charged. (For details, see "Periodic Battery Charging" in this chapter.)

Then disconnect the battery from the unit. To do this, follow the steps listed below.

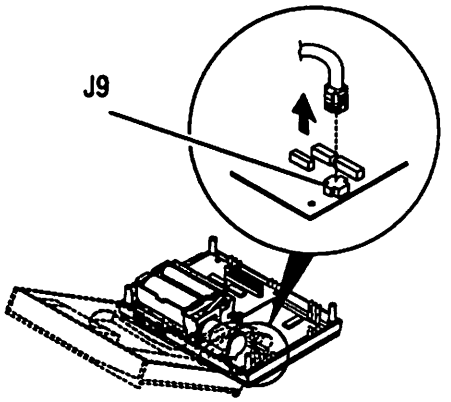
- Use the  switch to remove power. Unplug power module, if connected. Unplug any other external connectors, as well.

> **NOTE**
>
> In order to prevent damage to the pcb assemblies, be sure that you are connected to an anti-static strap. Be careful not to bend the pcb assemblies.

- Remove the outside screws which hold the 2 halves of the unit together.

- Lift top and turn over carefully. The 2 halves of the unit are connected by cabling.

Storage Guidelines (Cont)

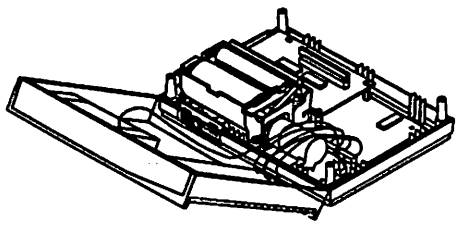


NOTE

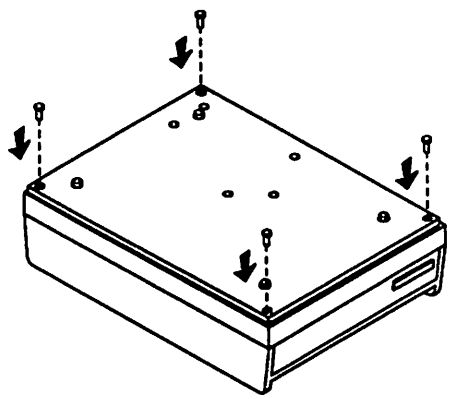
You MUST disconnect the battery cable from J9 on the processor pcb assembly first. Failure to do so could cause severe damage to the processor pcb assembly.

- Disconnect the battery cable from J9 on the processor pcb assembly.

Check that cables are out of the way.



- Before closing the unit, check to make sure that all cables/ harnesses are tucked out-of-the-way and will not be crimped or pinched when unit is closed.



- Replace screws in base.

The unit can be stored safely for an indefinite period.

Visual Inspection

Visually inspect the MAC PC electrocardiograph to uncover "simple" problems.

This visual inspection procedure looks for "obvious" problems in the unit. Simple failures such as disconnected cables, foreign debris on a printed circuit board, bad repairs, or even missing hardware can quite seriously affect operation.

These "simple" failures can appear to be completely different problems to the user or repair technician, making the troubleshooting process very difficult. The following steps might seem trivial but it is highly recommended that they be performed to remove these failures as causes of problems in the unit.

To begin, open the unit for service. (For details, see paragraphs titled "Basic Disassembly" in this chapter.)

Remove "auxiliary board".

- If an EPROM expansion pcb assembly, pn 85676-XXX, modem pcb assembly, pn 85637-XXX, or analog output pcb assembly, pn 85843-XXX (hereafter referred to as the "auxiliary board"), is present, remove it, too. The processor pcb assembly is now exposed.

Check each printed circuit board for foreign materials.

- Check both printed circuit board for any moisture or debris. (Don't bother checking the bottom of the processor pcb assembly, since removing it is fairly involved.) If much moisture or debris is found, determine the source of the pollution. Make sure the printed circuit board is cleaned before installing it back in the unit.

Check each printed circuit board for loose components.

- Check each printed circuit board to make sure all components are intact. Socketed components should be firmly seated in their respective sockets. Check that the components are properly soldered to the printed circuit board, especially components added as part of modifications or repairs.

Check for failed components.

- Something to look for when checking over the printed circuit boards is burn damage from overheated components. The familiar smell of a burned component (resistor) is a dead giveaway that something has failed, even if the component has not been discolored.

Check all cables.

- Check all interface cables to make sure they are firmly connected. There should be no excessive tension on any of the cables nor should they be showing signs of excessive wear.

Replace auxiliary board.

- Replace the auxiliary board, making sure a good connection is made between connector J1 on auxiliary board and connector J1 on processor pcb assembly. Make sure that all ground straps are connected.

Make sure all required mounting hardware is properly installed.

- Make sure that all the screws and other mounting hardware are in place and are properly installed. Sometimes these fasteners are used as connections to ground planes on the printed circuit boards. Failure to properly connect the ground planes could result in corrupted data, among other things.

Reprogram the setup after closing the unit.

- Close the unit as described in the paragraphs titled "Basic Reassembly" in this chapter.

Thermal Paper Storage

Marquette Thermal Paper

To avoid deterioration or fading of traces, follow these precautions:

1. Store in cool, dark and dry locations. Temperature must be below 80°F (27°C). Relative humidity must be between 40% and 65%.

2. Avoid exposure to bright light or UV sources such as sunlight, fluorescent and similar lighting which cause yellowing of paper and fading of tracings.

3. DO NOT STORE THERMAL PAPERS WITH ANY OF THE FOLLOWING:

- Carbon and carbonless forms
- Non-thermal chart papers or any other products containing tributyl phosphate, dibutyl phlhalate or any other organic solvents. Many medical and industrial charts contain these chemicals.
- Document protectors, envelopes and sheet separators contain PVC or other vinyl chlorides.

4. AVOID CONTACT WITH: cleaning fluids and solvents such as alcohols, ketones, esters, ether, etc.

5. DO NOT USE: mounting forms, pressure-sensitive tapes or labels containing solvent-based adhesives.

To assure MAXIMUM TRACE IMAGE LIFE, thermal paper should be stored separately in:

Manila folders
Polyester or polyimide protectors

Plastic document protectors, envelopes or sheet separators made of polystyrene, polypropylene or polyethylene will not degrade thermal traces in themselves. However, these materials afford no protection against fading from external causes.

Use only mounting forms and pressure sensitive tapes made with starch or water-based adhesives.

Paper manufacturers advise us that these thermal products should retain their traces when properly imaged and stored for about 3-5 years. If your retention requirements exceed these guidelines, we recommend you consider alternate image storage technologies.

Thermal Paper Storage (Cont)

Archivist Thermal Paper

MARQUETTE ELECTRONICS warrants that the image produced on Archivist papers by MARQUETTE equipment will not fade for seven (7) years when handled before and after use according to the instructions outlined below.

Storage Conditions: Archivist papers must be continuously stored below 40 degrees Centigrade, and relative humidity must be maintained between 40% and 60%.

Notice to MARQUETTE: Customer is obliged to notify MARQUETTE promptly following any customer knowledge of any fading.

The MARQUETTE equipment used shall have periodic maintenance performed in accordance with MARQUETTE service manuals and/or technical memorandums.

The liability of MARQUETTE ELECTRONICS hereunder is limited in all circumstances to the costs of the reproduction of patient records. The express warranty herein provided is given in lieu of any and all other warranties, expressed or implied, INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY AND IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE.

This warranty applies to Archivist brand papers and does not apply to any other thermal paper sold by MARQUETTE ELECTRONICS.

MARQUETTE reserves the right to withdraw or alter this warranty at any time with respect to paper bought hereafter.

Cleaning

Before starting, turn off the MAC PC electrocardiograph.

Disconnect the power module from the unit. With the unit turned off, clean it with a clean soft cloth and a solution of mild dishwashing detergent diluted in water. The cloth should be wrung out reasonably dry.

Wipe the exterior of the case carefully. Avoid contact with open vents, plugs, and connectors of any kind, keyboard, and thermal writer. Wipe dry with a soft clean cloth or paper towel.

Clean reusable electrodes thoroughly each day.

After each use, reusable electrodes should be wiped with a tissue or damp cloth to clean them of electrode paste. At the end of each day, reusable electrodes should be washed thoroughly with soap and water and dried. For suction electrodes, a toothbrush may be used to clean out the cups.

Check interior surfaces for dust.

The interior surface of the unit should be checked regularly for excessive dust buildup. Precision dust removers which are available commercially and function like compressed air to blow away accumulated dust can be used.

Clean the thermal print head at least once a month.

Clean the thermal print head at least once a month. With heavy use or if other than Marquette thermal paper is used, there may be a buildup of paper residue on the thermal print head and/or capstan/roller which will degrade thermal print head performance. That is, the printing may be light or uneven. If this is happening, clean the thermal print head more often.

Cleaning the thermal print head and the capstan/roller in the writer 1 is a very simple procedure.

Cleaning the thermal print head and the capstan/roller in the writer 1 is a very simple procedure and is explained below. Cleaning the thermal print head and capstan/roller in the writer 2 is much more involved. This procedure is explained in the paragraphs titled "Thermal Print Head Cleaning" in chapter 8, Writer 2.

Before starting this cleaning procedure, verify that the unit is turned off.

For the writer 1, open the writer door and remove the thermal paper. You will need a sterile gauze pad or cotton swab moistened with alcohol to clean the thermal print head. Carefully wipe clean the thermal print head face.

Do not use alcohol on the capstan/roller

Do not use alcohol on the capstan/roller since the alcohol dries the rubber compound used in the capstan/roller. This results in warping and cracking of the capstan/roller.

Instead use a typewriter-style platen cleaner to clean the capstan/roller. Wipe off the capstan/roller with the typewriter-style platen cleaner.

Let the capstan/roller dry completely before replacing the thermal paper.

Equipment Safety Tests

Introduction

When the MAC PC electrocardiograph is used with the PM-3 power module, which is not double insulated, a leakage test is required.

The following paragraphs contain equipment safety tests to ensure that the MAC PC electrocardiograph poses no electrical health hazards.

Since the MAC PC electrocardiograph, PM-1 power module, and PM-2 power modules are double insulated, a leakage test is not required. However, when the MAC PC electrocardiograph is used with the PM-3 power module, which is not double insulated, a leakage test is required.

The last 2 tests involve the acquisition module itself and are done with the acquisition module plugged into the MAC PC electrocardiograph.

Failure to implement a satisfactory maintenance schedule may cause undue equipment failure and possible health hazards. Unless an Equipment Maintenance Contract exists, Marquette Electronics does not in any manner assume the responsibility for performing this recommended safety checkout procedure. The sole responsibility rests with the individual or institution using the equipment.

Equipment safety tests be performed every 6 months and every time a circuit board/assembly is removed and replaced in the unit. There are 2 types of safety tests; MAC PC electrocardiograph leakage tests and acquisition module leakage tests. The table below lists tests for the unit. (See the Preventive Maintenance Inspection Report in this chapter for additional information.)

Applicable Leakage Tests

	TEST	APPLIES TO
1	Ground-wire-leakage-to-ground	MAC PC electrocardiograph
2	Chassis-leakage-to-ground (exposed chassis)	MAC PC electrocardiograph
3	Patient-cable-leakage-to-ground	Acquisition module (patient cable)
4	Patient-cable-leakage-into-patient-leads-from-115 V ac	Acquisition module (patient cable)

Equipment Safety Tests (Cont)

Maximum Conditions

The table below lists the maximum allowable leakage currents for the 4 safety tests.

Maximum Allowable Leakage Currents

	TEST	MAXIMUM CURRENT (µA)
1	Ground-wire-leakage-to-ground	100
2	Chassis-leakage-to-ground (exposed chassis)	100
3	Patient-cable-leakage-to-ground	10
4	Patient-cable-leakage-into-patient-leads-from-115 V ac	10

⚠WARNING

The total system chassis risk current must not exceed 100 microamperes.
Otherwise, serious injury or death could result.

M15287-98

In units used outside the United States and Canada, the total system chassis risk current must not exceed 500 µA.

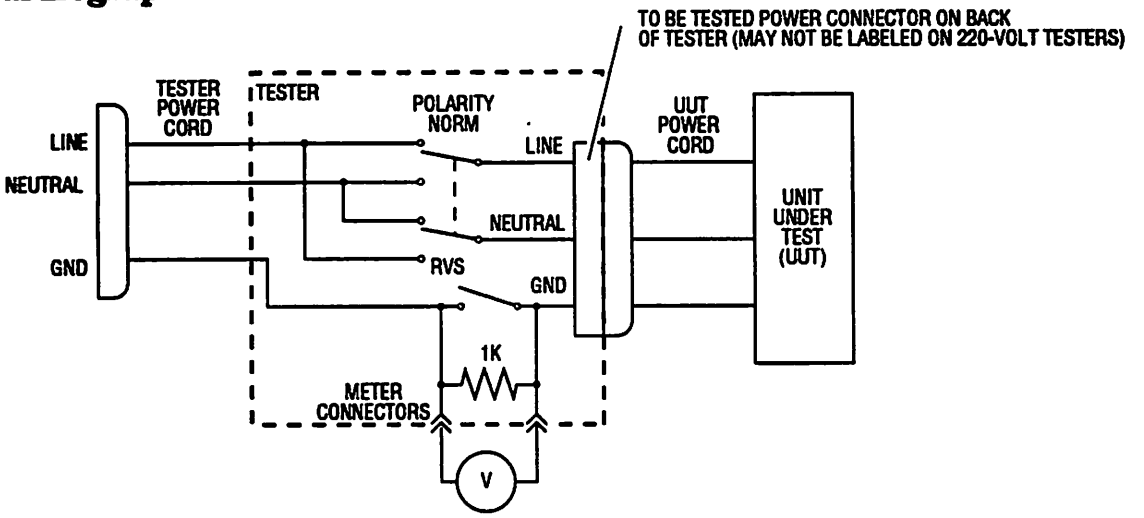
Equipment Safety Tests (Cont)

Preparation for Tests

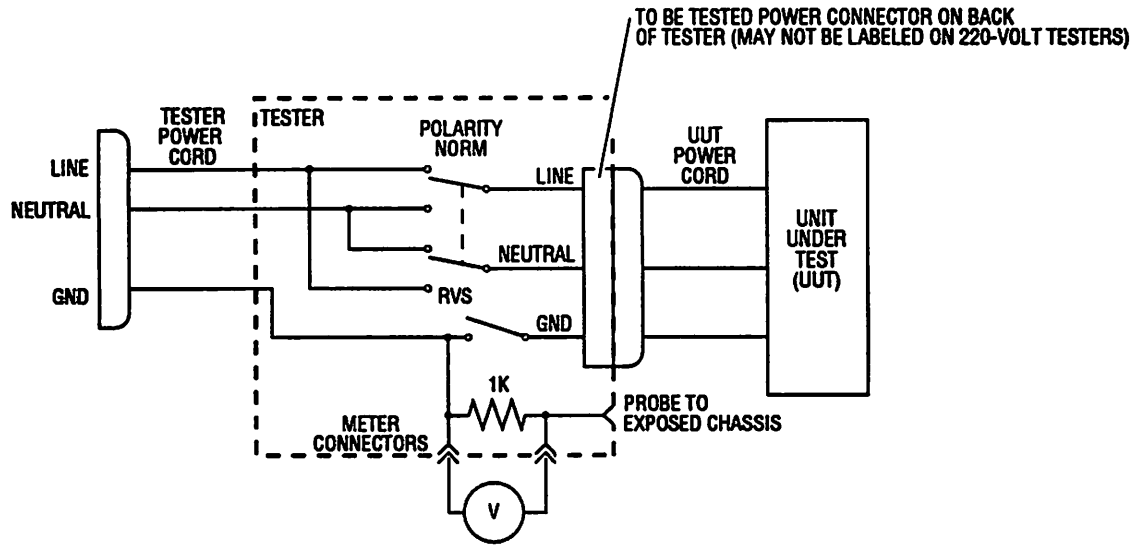
Verify that a properly wired outlet is used to furnish power to the assembly being tested.

> **NOTE**
>
> Do not proceed until a properly wired outlet is found. (For details, see the paragraphs titled "Power Source Verification" in chapter 4, General Troubleshooting.)

Applicable Electrocardiograph Tests



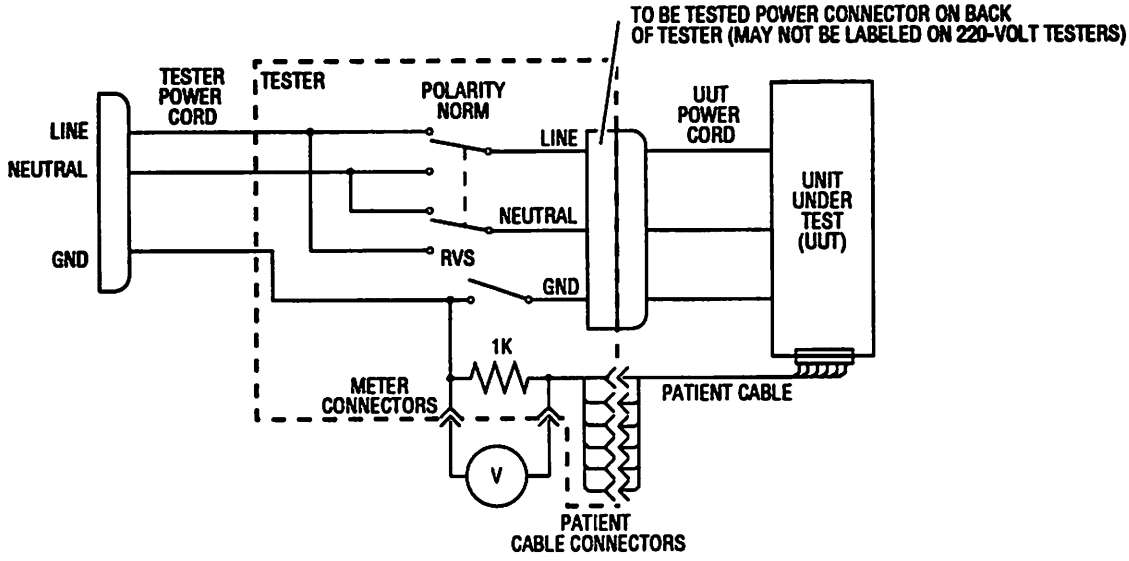
Test #1: Ground-Wire-Leakage-to-Ground Test, Schematic Diagram



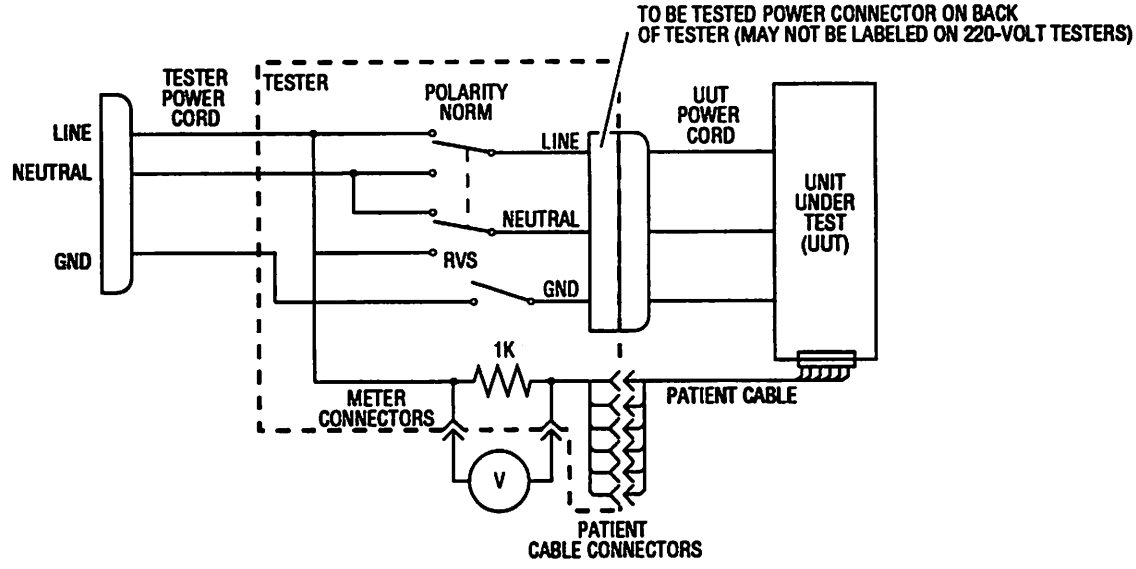
Test #2: Chassis-Leakage-to-Ground (Exposed Chassis) Test, Schematic Diagram

Equipment Safety Tests (Cont)

Applicable Acquisition Module Tests



Test #3: Patient-Cable-Leakage-to-Ground Test, Schematic Diagram



Test 4: Patient-Cable-Leakage-into-Patient-Leads-from-115 V AC Test, Schematic Diagram

NOTE

115 V ac will be applied to the acquisition module (patient cable) output connectors, tester connector, and digital multimeter leads.

NOTE

Ensure the leadwires do not contact conductive materials such as metal handles or railings and are not coiled or placed on the floor. Erroneous readings may result from these conditions.

NOTES

Chapter 4
General Troubleshooting

Chapter 4
General Troubleshooting (Cont)

Introduction

Use this chapter as a starting point for troubleshooting.

Use this chapter as a starting point for troubleshooting the MAC PC electrocardiograph. It contains many basic troubleshooting procedures that will rule out many common failures. Where necessary, procedures in this chapter refer to the following chapters. Later chapters describe a particular component in the unit—power module, writer 2, modem, etc.

This chapter includes:

- block diagram theory of operation for the overall unit and detailed information on the operation of the processor pcb assembly,
- descriptions of all input and output connectors,
- a power source verification procedure to eliminate problems due to faulty wiring,
- how to troubleshoot problems occurring during the powerup selftest,
- descriptions of the unit's operating characteristics as determined by the software version, including the procedures for installing software,
- summarized information on the various types of acquisition modules to rule out incompatibility issues,
- procedures for troubleshooting poor quality ECG traces which review environment, patient preparation, and electrode placement requirements,
- an overview of how the unit produces the multi-lead electrocardiogram (lead formation), and finally
- what to do about problems caused by electrostatic discharge.

Theory of Operation

Introduction

The information on theory of operation begins with a brief discussion of the pcb assemblies in the acquisition module. Functional descriptions and block diagrams of both the AM-3 and AM-4 acquisition modules are included. With the release of software version 108, the MAC PC electrocardiograph ships with an AM-4 acquisition module. MAC PC electrocardiograph CAPOC units continue to ship with an AM-3 acquisition module.

This is followed by block diagram theory of operation for the overall MAC PC electrocardiograph. Block diagrams showing the optional configurations (modem or analog output) are included as well.

The concluding theory of operation discussion contains detailed information on the operation of the processor pcb assembly.

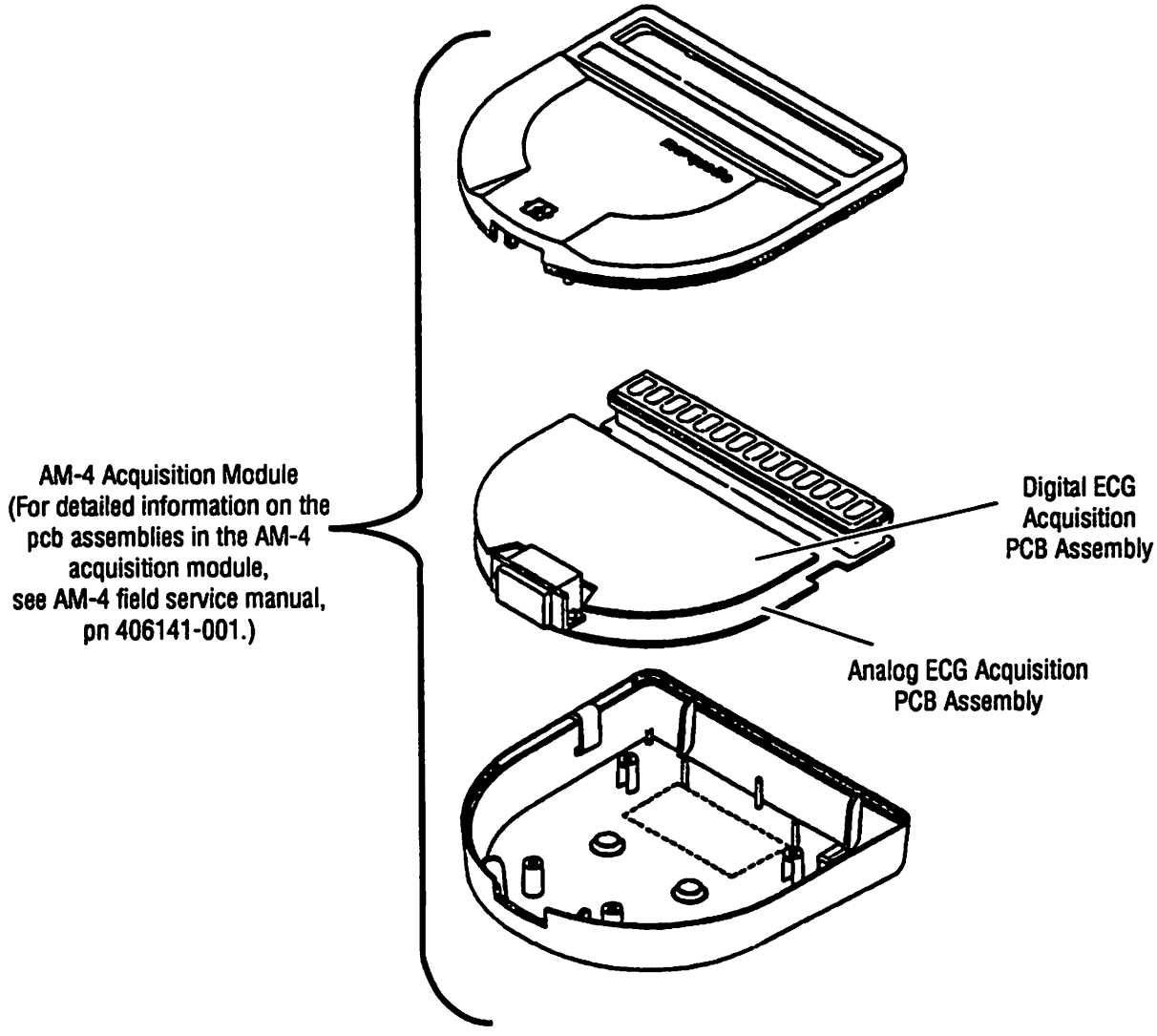
Theory of Operation (Cont)

Assemblies in the AM-4 Acquisition Module

The analog ECG acquisition pcb assembly and digital ECG acquisition pcb assembly form the acquisition module. ECG signals from the patient electrodes are applied to the inputs of the analog ECG acquisition pcb assembly. There the ECG signals are amplified, filtered, multiplexed, and digitized.

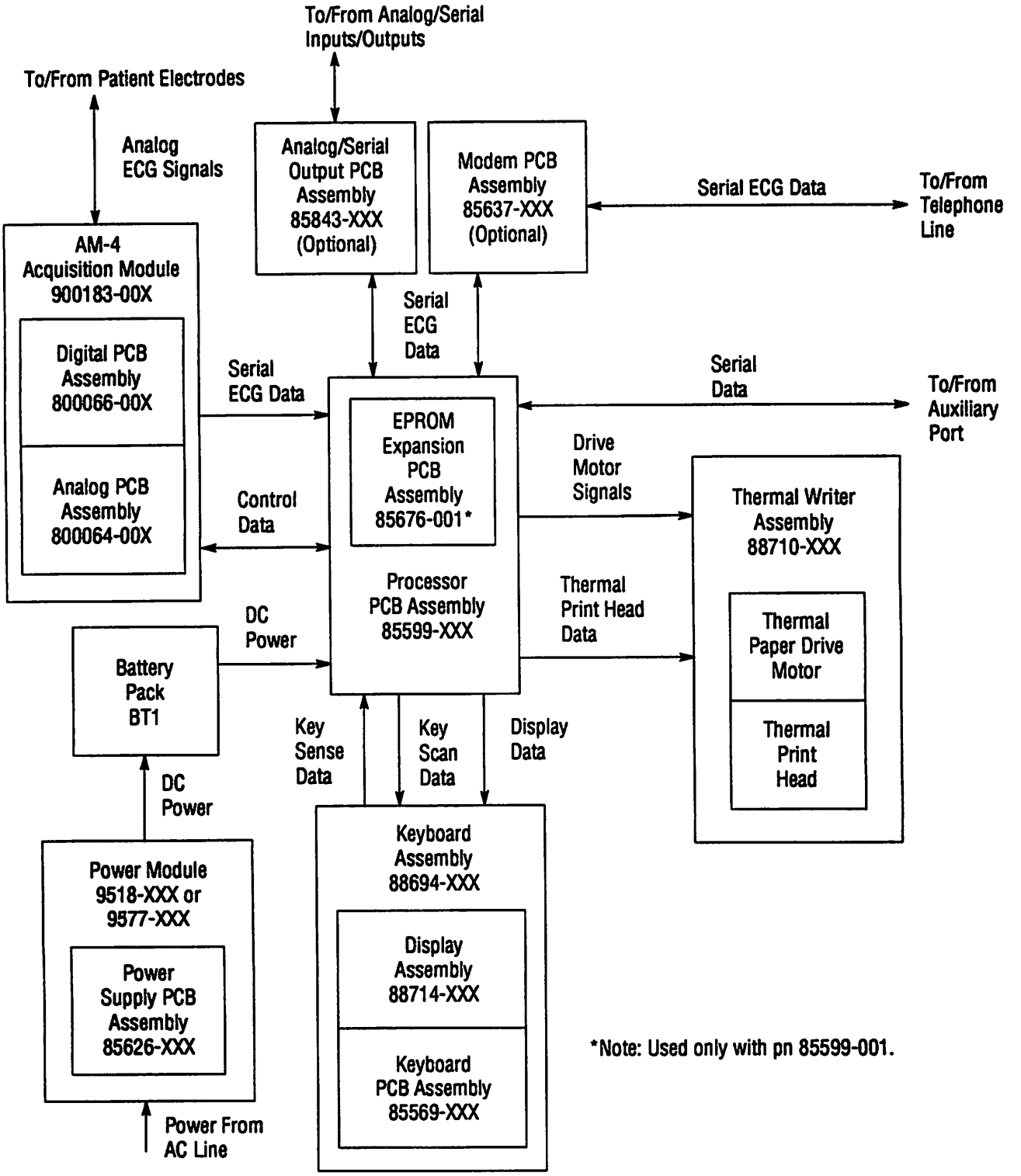
The signals are then applied to the digital ECG acquisition pcb assembly where further processing and filtering is performed. The data is then optically isolated and passed on to the patient cable transition pcb assembly in the MAC PC electrocardiograph. The digital ECG acquisition pcb assembly also provides the isolation power supplies for the acquisition module.

The AM-4 acquisition module is not compatible with MAC PC electrocardiograph CAPOC units.



Theory of Operation (Cont)

MAC PC Electrocardiograph w/ AM-4 Acquisition Module Block Diagram



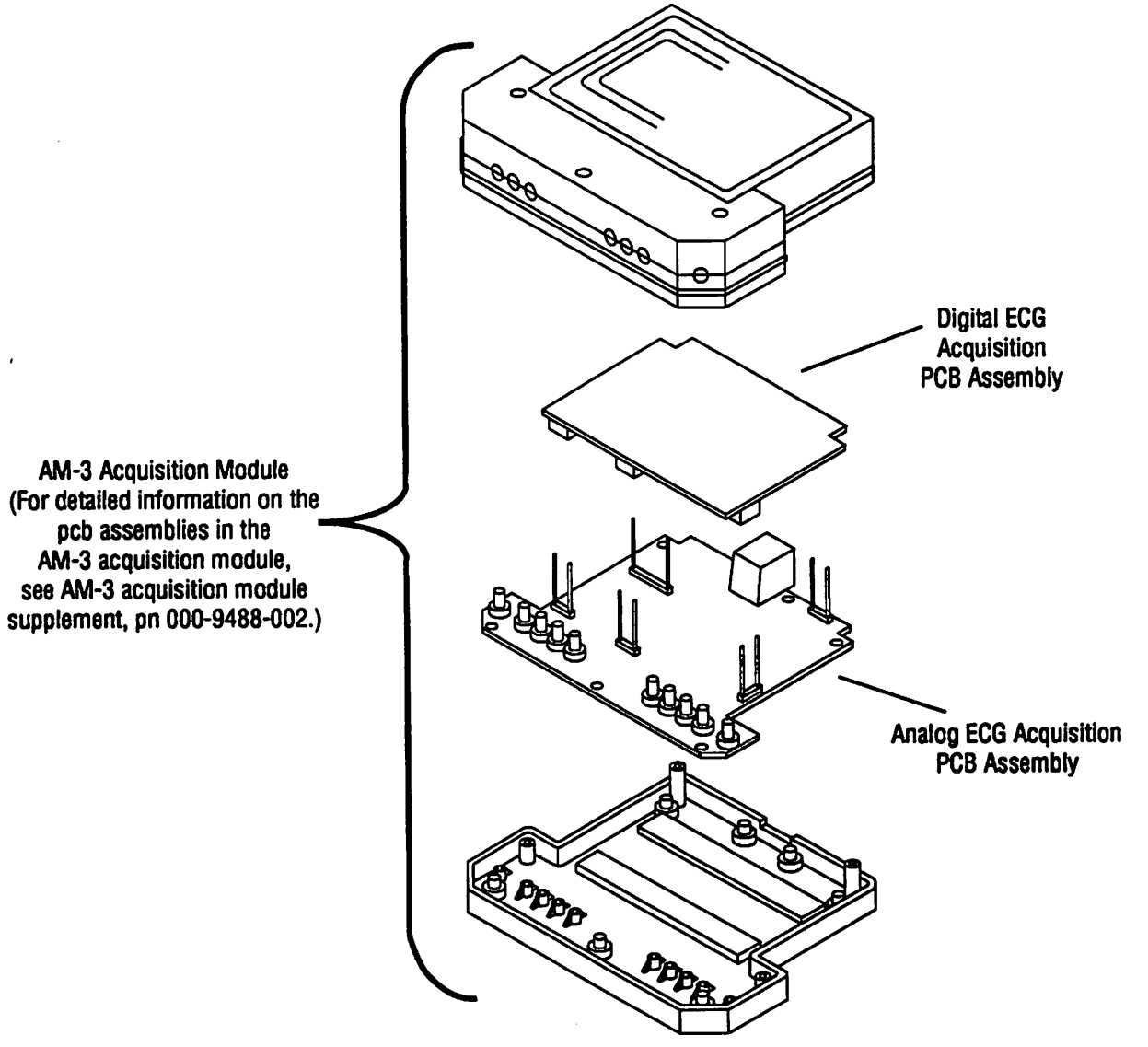
Theory of Operation (Cont)

Assemblies in the AM-3 Acquisition Module

The analog ECG acquisition pcb assembly and digital ECG acquisition pcb assembly form the acquisition module. ECG signals from the patient electrodes are applied to the inputs of the analog ECG acquisition pcb assembly.

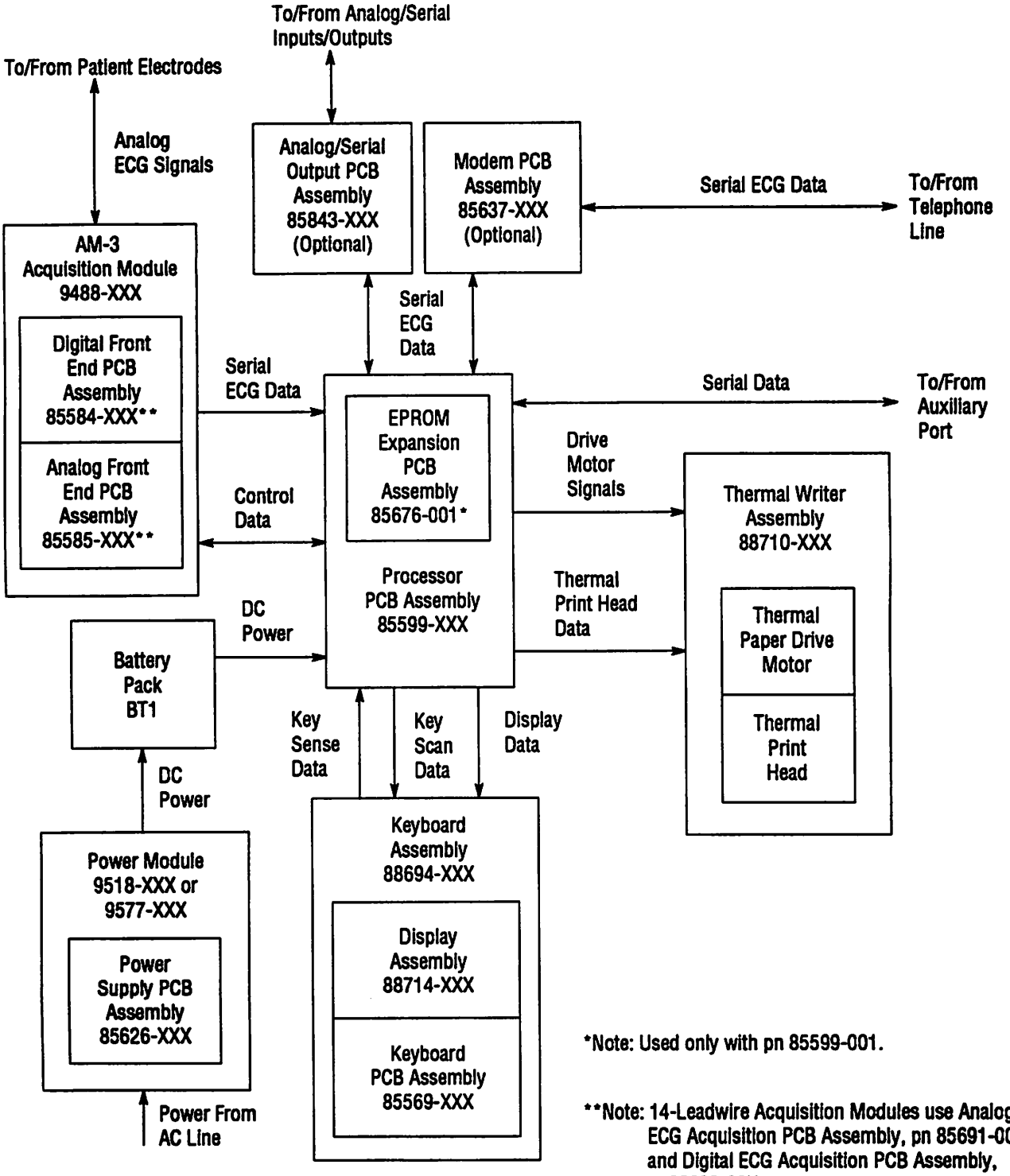
There the ECG signals are amplified, filtered, and applied to the digital ECG acquisition pcb assembly. Digitized, multiplexed data is returned from the digital ECG acquisition pcb assembly. This data is optically isolated and passed on to the patient cable transition pcb assembly in the MAC PC electrocardiograph. The digital ECG acquisition pcb assembly also provides the isolation power supplies for the acquisition module.

The AM-3 acquisition module should be used with MAC PC electrocardiograph CAPOC units.



Theory of Operation (Cont)

MAC PC Electrocardiograph w/ AM-3 Acquisition Module Block Diagram



*Note: Used only with pn 85599-001.

**Note: 14-Leadwire Acquisition Modules use Analog ECG Acquisition PCB Assembly, pn 85691-00X, and Digital ECG Acquisition PCB Assembly, pn 85692-00X.

Theory of Operation (Cont)

The following paragraphs contain block diagram theory of operation for the overall MAC PC electrocardiograph. An overall block diagram of the unit is shown on the next page. Block diagrams showing the modem configuration and the analog output configuration conclude the discussion.

Processor PCB Assembly

The processor pcb assembly contains 2 different microprocessors. One is a 68000 microprocessor which performs the acquisition, processing, analyzing, and printing of the ECG data. The other microprocessor is a 65C02 that controls hardware functions such as keyboard, display, thermal paper drive motor, battery recharging, and power distribution to the 68000 microprocessor and other circuits.

The 65C02 microprocessor is a low-power CMOS version of the 6502 microprocessor. The processor pcb assembly contains a real-time clock to provide the time of day when the ECG forms are printed.

The 68000 microprocessor controls the acquiring of ECG data from acquisition module. Once the data has been acquired by the processor pcb assembly, the 68000 microprocessor converts the data to a form that can be used to print the ECG waveforms by the thermal print head. The 68000 microprocessor also performs the Marquette 12SL analysis program on the ECG data. The analysis is printed along with the ECG waveforms. The actual printing sequence is performed by the 68000 microprocessor. The 65C02 microprocessor controls the thermal paper drive motor.

Auxiliary Port

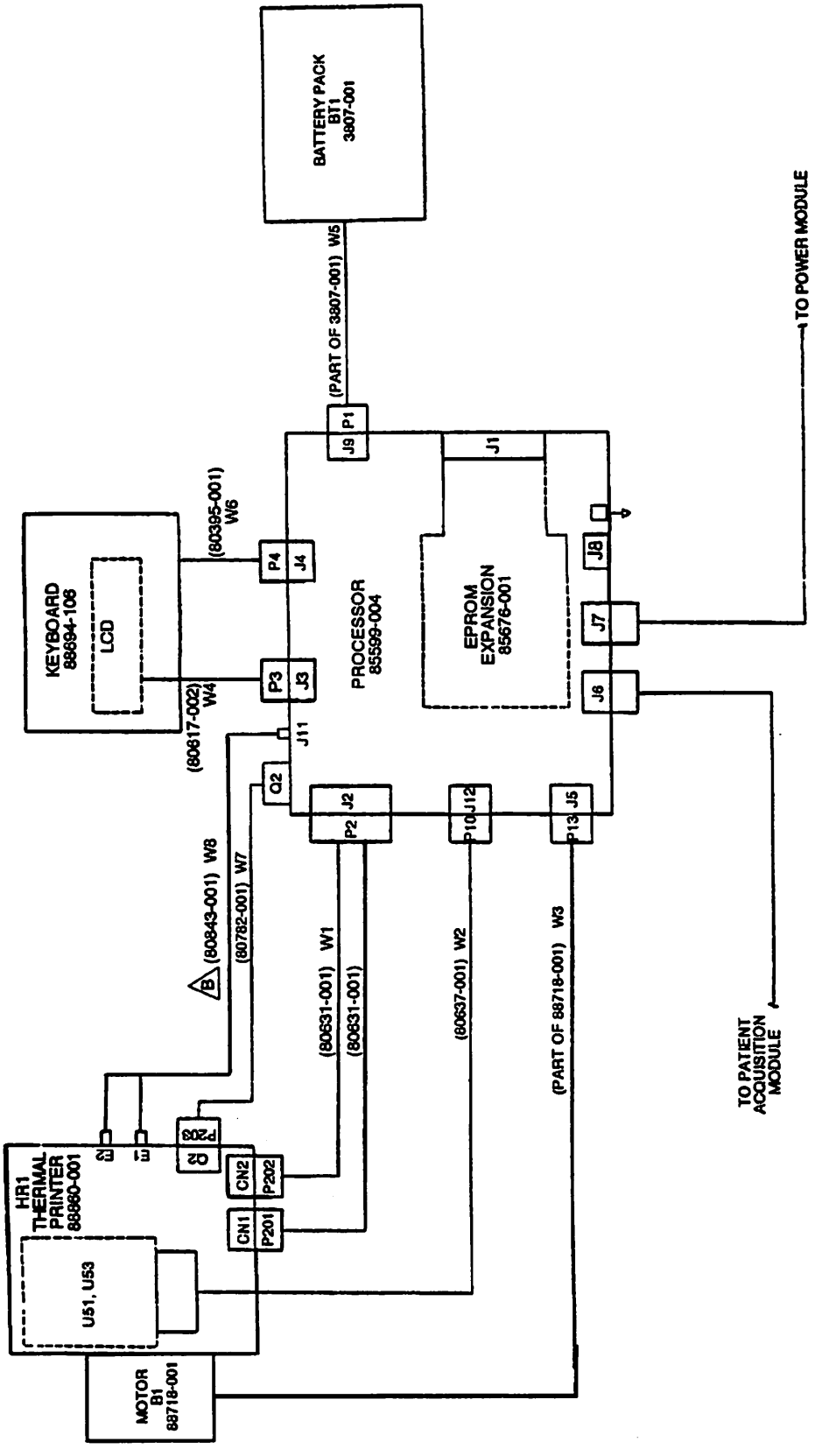
An auxiliary port J8 on the processor pcb assembly, sends serial data to and from another MAC PC electrocardiograph, or to and from a MUSE system diskette reader. (The MUSE system is a computerized system for the acquisition, analysis, storage, and retrieval of ECG data.) This allows ECGs to be transferred without using the optional modem pcb assembly, requiring only a connecting cable between the 2 devices.

EPROM Expansion PCB Assembly

This pcb assembly contains 2 EPROMs and an address decoder, and is attached to the processor pcb assembly. It is present only on the pn 85599-001 version of the processor pcb assembly. On the pn 85599-002 and later versions of the processor pcb assembly, the components of the EPROM expansion pcb assembly are incorporated in the processor pcb assembly.

Theory of Operation (Cont)

MAC PC Electrocardiograph Overall Block Diagram



Theory of Operation (Cont)

Battery Pack

The MAC PC electrocardiograph has an internal nickel-cadmium battery pack which is rechargeable. The battery pack supplies all the voltages necessary for operation of the unit.

If the battery pack is discharged too far, the individual cells in the battery pack can be damaged. To prevent damage, a circuit on the processor pcb assembly monitors the amount of charge remaining in the battery pack. When the battery pack reaches the bottom of its useful charge cycle, the processor pcb assembly prevents further use of the unit until the batteries are recharged.

Power Module

The power module, which contains the power supply pcb assembly, is powered from a standard 120-volt or 240-volt ac power outlet. The power module performs 2 functions. First, it recharges the unit's internal battery pack. Second, the power module functions as an ac power supply for the MAC PC electrocardiograph. The power module can't supply enough power by itself to operate the unit under high-current conditions, such as printing an ECG. However, if the power remains connected, the batteries will be recharged over a period of time, because the power module will produce more power than the unit consumes.

Power Control

A 65C02 microprocessor in the processor pcb assembly monitors power consumption within the unit. The 65C02 microprocessor, which uses very little power itself, controls power distribution to other circuits in the unit. The 68000 microprocessor, uses much more power than the 65C02 microprocessor. The 65C02 microprocessor shuts off power to the 68000 microprocessor when the 68000 microprocessor is not needed. This helps extend the running time between battery rechargings. The 65C02 microprocessor also controls switching of various power buses within the unit.

Keyboard Assembly

Operator-entered information is input to the unit via the keyboard assembly. The keyboard assembly contains the keyboard pcb assembly and the display assembly which uses a liquid-crystal display (lcd). The keyboard pcb assembly contains switches that close when the keys on the keyboard are depressed. The processor pcb assembly reads the entries on the keyboard by sending out key scan data and reading back key sense data.

The 65C02 microprocessor monitors the keyboard for entries, and accepts operator-entered data. Operator prompts, error messages, and status messages to be displayed on the lcd are also controlled by the 65C02 microprocessor. The lcd has its own microprocessor to reduce the amount of work required by the processor pcb assembly during data transfers to the lcd.

Theory of Operation (Cont)

Thermal Writer Assembly

Thermal paper copy output of ECG waveforms and printed data are generated by the thermal writer assembly. The thermal writer assembly contains the thermal paper drive motor and the thermal print head. The thermal print head contains shift registers and latches to simplify data transfer between the processor pcb assembly and thermal print head.

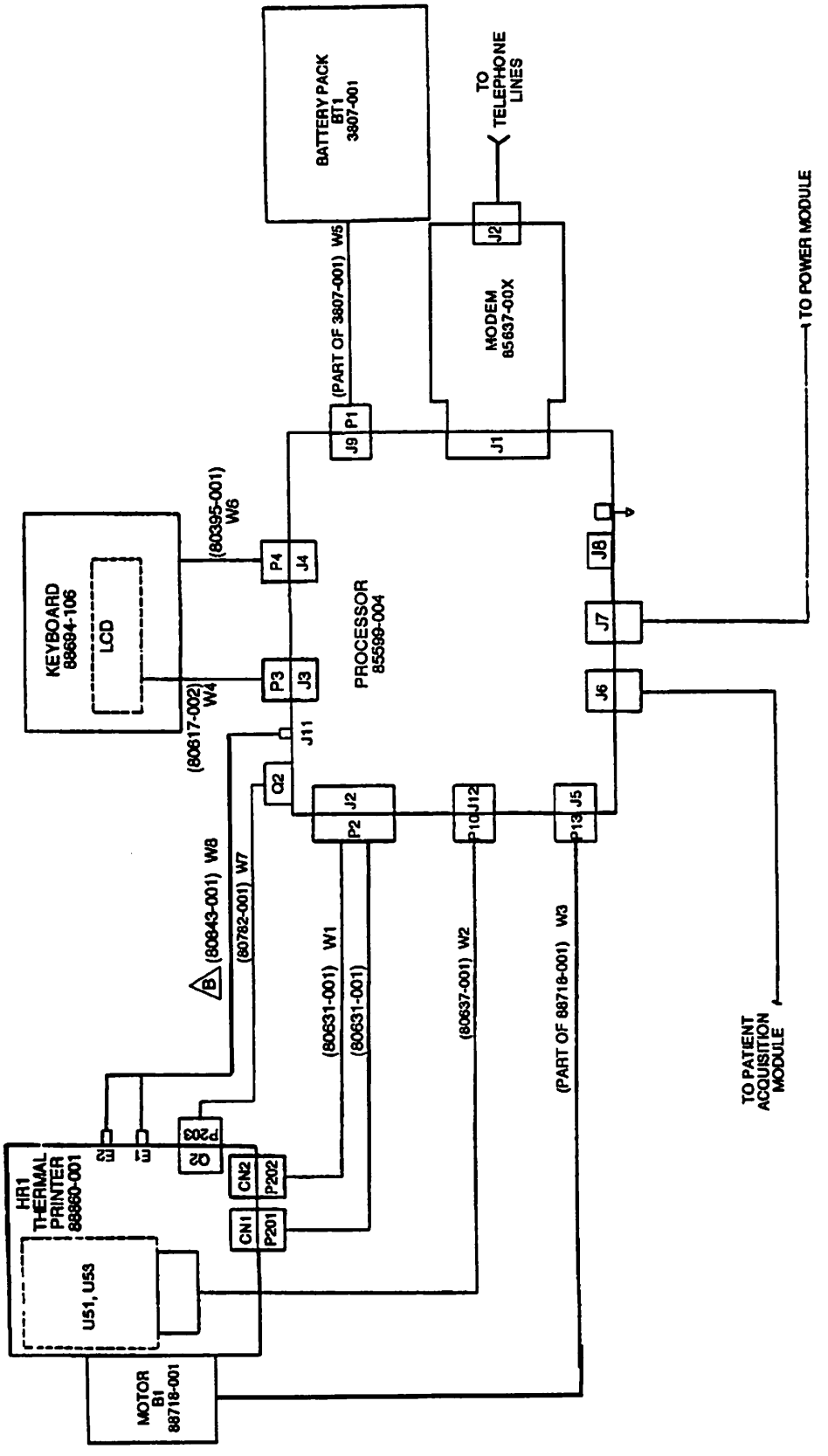
The thermal paper drive motor is driven by the processor pcb assembly. The speed of the motor is regulated by an optical tachometer and feedback system. The thermal paper drive motor is a dc motor which is controlled by the 65C02 microprocessor.

Modem PCB Assembly

The optional modem pcb assembly transmits ECGs stored on RAM on the processor pcb assembly to a MUSE central ECG system via telephone lines. Digital ECG data is used to modulate an audio carrier signal, creating an audio-frequency signal which carries ECG data. The audio-frequency signal transfers data at 2400 bits per second to another modem at the MUSE central system. The modem at the distant end converts the ECG data back to digital form. (See block diagram on following page.)

Theory of Operation (Cont)

MAC PC Electrocardiograph with Modem PCB Assembly Block Diagram



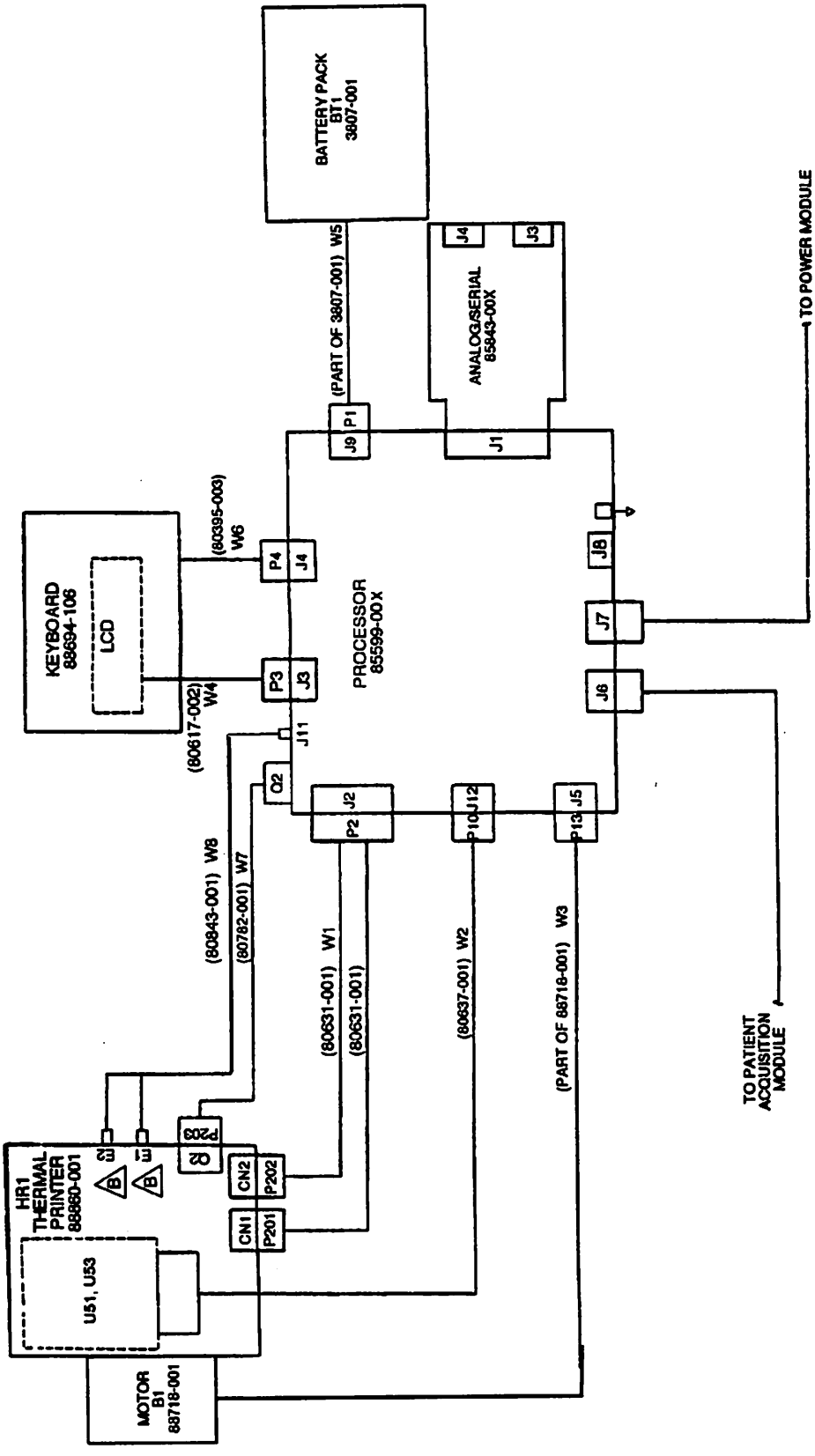
Theory of Operation (Cont)

Analog PCB Assembly

The optional analog pcb assembly provides 4 channels of analog output and 1 channel of bidirectional asynchronous serial communication. The analog output channels can be used to display ECG waveforms on a user-supplied oscilloscope. The asynchronous communication channel allows the analog/serial output pcb assembly to communicate with RS232 devices. (See block diagram on following page.)

Theory of Operation (Cont)

MAC PC Electrocardiograph with Analog PCB Assembly Block Diagram



Theory of Operation (Cont)

Processor PCB Assembly Block Diagram Theory

The concluding paragraphs of the theory of operation chapter contain detailed block diagram theory for the processor pcb assembly.

Two microprocessors, 68000 and 65C02, are used to control all functions of the unit.

The processor pcb assembly uses 2 microprocessors, 68000 and 65C02, to control all functions of the MAC PC electrocardiograph. The 68000 microprocessor:

- controls ECG data acquisition from the patient block assembly,
- analyzes the ECG data,
- generates thermal print head data for printed reports,
- controls power to the thermal print head,
- interprets data acquired from the keyboard by the 65C02 microprocessor, and
- controls software menus displayed on the lcd (liquid-crystal display) by the 65C02 microprocessor.

The 65C02 microprocessor:

- scans the keyboard for user entries,
- outputs data from the 68000 microprocessor to the lcd,
- controls the thermal paper drive motor in the thermal writer assembly,
- regulates the thermal head voltage in the thermal writer assembly,
- controls recharging of the battery pack, and
- controls power to the 68000 microprocessor and other circuits on the processor pcb assembly.

To conserve power, circuits are only supplied with power when their functions are needed.

The last function listed for the 65C02 microprocessor is a bit out of the ordinary. Since the unit was designed to operate on (limited) battery power, a system had to be devised which used as little power as possible.

When the unit is turned on, power consumption is minimized by only applying power to a circuit when the circuit's function is needed. For example, the 65C02 only applies power to the 68000 microprocessor when one of the 68000 microprocessor's functions need to be performed (ie, a transfer of data from the patient block assembly, processing of the data, or generation of a printed report).

Theory of Operation (Cont)

Even when the unit is off, a clock/ calendar program is executed.

When the unit is turned off, a real-time clock turns on the 65C02 microprocessor every 128 seconds. The 65C02 microprocessor executes a clock/calendar program to update the time and date stored in memory, then turns itself off. (See details in the power supply circuit description.) Note that when the unit is on, the real-time clock still causes the 65C02 microprocessor to update the time and date by generating an interrupt every 128 seconds.

When the 65C02 turns off the 68000 to conserve power, external logic must be used to refresh the dynamic RAM.

Another unusual aspect of the design involves dynamic RAM refresh. When the 68000 microprocessor is powered up and executing software, it refreshes the dynamic RAM in the 68000 microcomputer circuit under software control. However, when the 65C02 microprocessor powers down the 68000 microprocessor to conserve power, the 68000 microprocessor can no longer refresh its dynamic RAM. External logic is then used to generate the 256 row addresses needed to refresh the dynamic RAM.

Functional Circuits

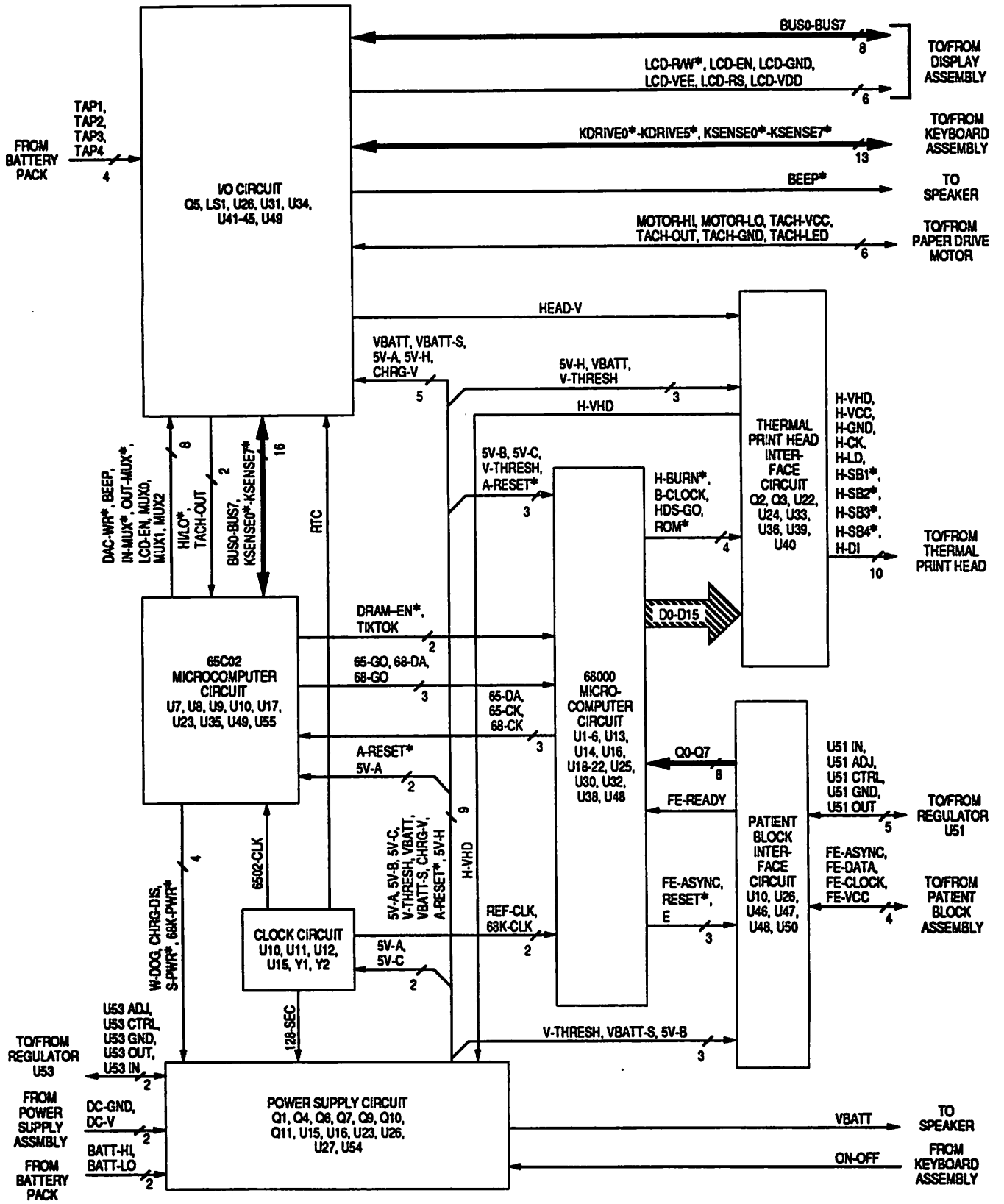
The processor pcb assembly is divided into 7 functional circuits.

The processor pcb assembly is divided into 7 functional circuits. (See the processor pcb assembly functional block diagram on the next page.) These are:

- the 68000 microcomputer circuit, which analyzes ECG data and controls the thermal print head interface circuit and patient block interface circuit,
- the 65C02 microcomputer circuit, which controls power to all circuits and controls the keyboard assembly, display assembly, speaker, and thermal paper drive motor in the thermal writer assembly through the I/O circuit,
- the power supply circuit, which powers the various circuits under control of the 65C02 and 68000 microcomputer circuits,
- the clock circuit, which supplies timing for the 68000 and 65C02 microcomputer circuits,
- the thermal print head interface circuit, which uses control and data signals from the 68000 microcomputer circuit to control the thermal print head,
- the patient block interface circuit, which supplies the 68000 microcomputer circuit with ECG data, and
- the I/O circuit, which interfaces the 65C02 microcomputer circuit with the keyboard assembly, display assembly, speaker, and thermal paper drive motor in the thermal writer assembly.

Theory of Operation (Cont)

Processor PCB Assembly Functional Block Diagram



Theory of Operation (Cont)

68000 Microcomputer Circuit

The 68000 microcomputer circuit performs 3 main functions. It acquires ECG waveform data from the patient block assembly through the patient block interface circuit, processes the ECG waveform data, and outputs text and waveform data to the thermal print head through the thermal print head interface circuit. It also generates lcd data for the display assembly and communicates with the 65C02 microcomputer circuit.

Dual-Function Signals

Two dual-function signals, 65-GO (65C02 go) and 68-GO (68000 go), are used by the 68000 microcomputer circuit. These signals are used primarily for 68000/65C02 microprocessor communication, and are described in the description of the 68000/65C02 microcomputer circuit communication link. Their secondary functions are described in the following paragraphs.

Upon powerup, the 65C02 microprocessor determines that the ON/OFF switch was pressed. It then applies a signal to the power supply circuit, which powers the 68000 microprocessor. Upon powerup, the 68000 microprocessor is held in the reset

65-GO state by the 65-GO signal from the 65C02 microprocessor.

When the 65C02 microprocessor removes 65-GO, the 68000 microprocessor does not immediately execute its operating program. Instead, it enters a software loop to refresh the dynamic RAM. This ensures that the transfer of dynamic RAM refresh control from external logic to 68000 software occurs smoothly.

After the 68000 microprocessor has assumed control of the dynamic RAM refresh, the 65C02 microprocessor applies a low 68-GO signal to the 68000 microprocessor. This causes the 68000 microprocessor to begin executing its normal operating software. 65-GO from the 65C02 microcomputer circuit is used to reset the 68000 microprocessor. If 65-GO stays low for too long, the RESET* signal is generated. The RESET* signal resets the 68000 microprocessor and some of the other circuits on the processor pcb assembly.

68-GO 68-GO, when held low long enough, generates a level 4 interrupt to the 68000 microprocessor. [Remember, for a 68000 microprocessor, 7 interrupts are possible, with level 7 (IPL1*, IPL2*, IPL3*=000) being the highest priority.] The interrupt causes the 68000 to execute its normal operating software (which includes dynamic RAM refresh).

V-THRESH, 65-GO, 68-GO V-THRESH (threshold voltage) is compared to 65-GO and 68-GO in the 68000 microcomputer circuit. If 65-GO or 68-GO stays low for a period of time (determined by an RC network), the comparator output goes low. This generates a reset (from 65-GO) or a level 4 interrupt (from 68-GO) to the 68000 microprocessor. V-THRESH should be approximately 1.5 volts.

Theory of Operation (Cont)

68000 Microcomputer Circuit (Cont)

Power Signals

The 68000 microcomputer circuit receives power from the power supply circuit through 5V-B and 5V-C. (The first version of the processor pcb assembly, pn 85599-001, used power signal 5V-D, which is the same as 5V-C.)

The 68000 microcomputer circuit receives power from interruptible supplies 5V-B and 5V-C (5V-D).

Interruptible supply 5V-B provides power to the 68000 microprocessor, EPROMs, and versatile interface adapter (VIA) along with some logic devices. 5V-B is taken to 5 volts whenever 68K-PWR* is taken low by the 65C02 microprocessor. (To conserve the batteries, the 65C02 microprocessor controls power to the 68000 microprocessor so that the 68000 is only powered when necessary.)

Continuous power is supplied to the dynamic RAM and external refresh logic.

Continuous 5V-C is applied to the 68000 microcomputer circuit so that the dynamic RAM in the 68000 microcomputer circuit can be refreshed when the 68000 microprocessor is halted, reset, or powered down by the 65C02 microcomputer circuit. 5V-C is continuous, so the refresh logic and dynamic RAM have power supplied at all times (except when the battery is dead).

Clock Signals

Two clock signals provide timing for the 68000 microcomputer circuit.

Two clock signals are applied to the 68000 microcomputer circuit from the clock circuit. They are 68K-CLK (68000 clock) and REF-CLK (refresh clock). 68K-CLK is an 8-MHz clock signal which is inverted to generate B-CLOCK (the 68000 microprocessor clock input). B-CLOCK is also applied to the thermal print head interface circuit to time thermal print head data transfers to the thermal print head.

REF-CLK is a 32.768-kHz signal applied directly to a counter in the 68000 microcomputer circuit. This counter applies refresh addresses to the dynamic RAM whenever the 68000 microprocessor is halted, reset, or powered down by the 65C02

Theory of Operation (Cont)

68000 Microcomputer Circuit (Cont)

Dynamic RAM Refresh

microcomputer circuit.

Two methods are used to refresh the dynamic RAM.

Dynamic RAM refresh is accomplished in one of two ways. When the 68000 microprocessor is operating normally, it refreshes the dynamic RAM under software control. When the 65C02 microcomputer circuit powers down the 68000 microprocessor (to conserve power), or the 68000 microprocessor is halted or reset, refresh must be accomplished by external logic.

When the 68000 is powered up, it refreshes dynamic RAM through software.

When the 68000 microprocessor is powered up, it is responsible for refreshing the dynamic RAM in the 68000 microcomputer circuit. The 68000 microprocessor uses TIKTOK (a synchronization line from the 65C02 microcomputer circuit), which has a period of 2 ms, to time the refresh. Refresh occurs in 2 bursts, 1 every 2 ms. Approximately half of the dynamic RAM is refreshed in each burst, so every memory location is refreshed every 4 ms.

To refresh the dynamic RAM, the 68000 microprocessor applies row addresses to the dynamic RAM, each followed by a row address strobe signal. When 1 row of the dynamic RAM is addressed, all cells in that row are refreshed.

When the 68000 is powered down, reset, or halted, refresh is performed by external logic.

When the 68000 microprocessor is halted, reset, or powered down by the 65C02 microcomputer circuit, it cannot refresh the dynamic RAM. In this case, dynamic RAM refresh is performed by external logic. DRAM-EN* (dynamic RAM enable*) from the 65C02 microcomputer circuit controls an address decode PLA (programmable logic array) in the 68000 microcomputer circuit.

The PLA generates row address strobe signals necessary for refresh. REF-CLK (refresh clock) from the clock circuit is used to increment a counter which generates the 256 row addresses needed to refresh all the dynamic RAM every 32 ms.

The slower refresh period (4 ms under software control versus 32 ms under external logic control) does not lose data because no bus activity occurs when the 68000 microprocessor is halted, reset, or powered down. Because the dynamic RAM is isolated from any data bus activity, no corruptive "noise" reaches the dynamic RAM and the longer refresh period can be used.

Theory of Operation (Cont)

68000 Microcomputer Circuit (Cont)

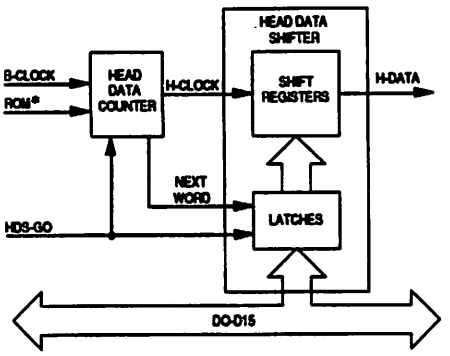
Thermal Print Head Interface Circuit Signals

The 68000 microcomputer circuit controls the thermal print head interface circuit.

The 68000 microcomputer circuit applies thermal print head data and control signals to the thermal print head interface circuit. A "head data shifter" in the thermal print head interface circuit converts 32 bits of parallel data into a serial stream. The serialized data is buffered and sent to the thermal print head.

The head data shifter accepts 1 long word of parallel data from the 68000 microcomputer circuit and converts it to a serial stream for use by the thermal print head.

The head data shifter consists of 2 parallel-load shift register ICs containing both latches and shift registers, counter, and some logic gates. Each shift register IC is capable of independently shifting 1 byte of data out while another byte is being loaded or held in its latches. Together, both ICs comprising the head data shifter accept 1 long word (32 bits) of parallel thermal print head data in 2 consecutive 68000 write operations before shifting the data out serially.



To output information to the thermal writer, the 68000 microcomputer circuit applies 1 word of data to data bus D0–D15. It then sets HDS-GO (head data shifter go) high. The rising edge of HDS-GO causes the head data shifter to latch the thermal print head data from data bus D0–D15. It also clears a counter referred to as the head data counter. The head data counter will, when enabled, clock thermal print head data out of the head data shifter.

The 68000 microcomputer circuit then applies a second word of data to D0–D15 and sets HDS-GO high. The rising edge of HDS-GO clocks the previously latched data into the shift registers and latches the second word of data from D0–D15.

After the second write of the long word write operation, the 68000 microprocessor continues to execute software stored in its EPROM. When the EPROM is accessed, ROM* (ROM enable*) is taken low to enable the EPROM outputs. ROM* also enables the head data counter, causing the head data counter to apply clock pulses to the head data shifter. The head data shifter then begins shifting the first word of data out on H-DATA. H-DATA is buffered and applied to the thermal print head as H-DI.

When the first word of thermal print head data has been clocked out of the head data shifter, NEXT WORD from the head data counter to the head data shifter latches goes high. The rising edge of NEXT WORD causes the second word of data to be clocked from the latch portion of the head data shifter to the shift registers. The data is then shifted out on H-DATA.

Theory of Operation (Cont)

68000 Microcomputer Circuit (Cont)

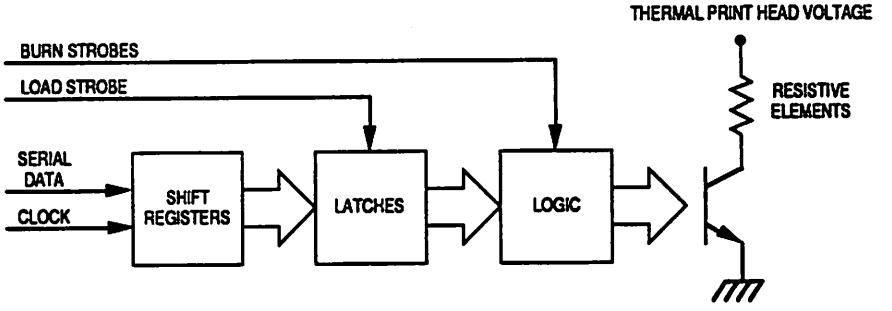
Thermal Print Head Interface Circuit Signals (Cont)

The clock signal for the head data shifter is derived from B-CLOCK.

B-CLOCK is used by the thermal print head interface circuit to derive clock signals for the head data shifter shift registers and the thermal print head. The head data counter divides B-CLOCK by 4 to generate the 2-MHz clock, H-CLOCK. Serial thermal print head data is clocked out of the head data shifter shift registers on the rising edge of H-CLOCK. The same data is clocked into the thermal print head on the falling edge of H-CLOCK.

Thermal print head theory

The thermal print head consists of resistive elements that "burn" a coating on the thermal paper when a voltage is applied. To control the thermal print head, thermal print head data from the processor pcb assembly is shifted serially into the thermal print head. In the thermal print head, the serial thermal print head data is shifted into parallel-output registers. A "load" signal loads the parallel outputs of the shift registers into latches. Next, a "burn" signal enables the output of the latches. Finally, a current flows through the resistive elements, burning the thermally-sensitive paper.



Load and burn signals are derived from H-BURN*.

H-BURN* (load/burn* strobe) is used by the thermal print head interface circuit to derive load and burn signals for the thermal print head. The load signal loads latches with data that has been shifted serially into shift registers in the thermal print head. The burn signal controls the resistive elements which actually "burn" the thermal paper. H-BURN* is monitored by the thermal print head interface circuit to prevent thermal print head burnout caused by H-BURN* remaining low for too long.

Theory of Operation (Cont)

68000 Microcomputer Circuit (Cont)

Patient Block Interface Circuit Signals

ECG data from the patient is transmitted to the processor pcb assembly 1 byte at a time, with an interbyte gap between bytes.

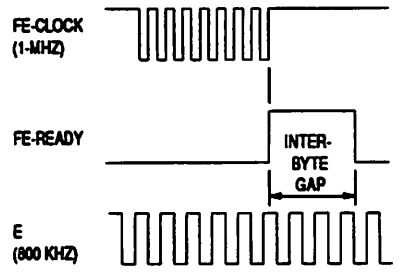
The patient block assembly accepts ECG data from the patient via leadwires. The patient block assembly buffers, filters, digitizes, and transmits the data to the processor pcb assembly. Data transmitted to the processor pcb assembly from the patient block assembly is transmitted 1 byte at a time with an interbyte gap between.

A signal from the patient block assembly clocks data into the patient block interface circuit.

Two clock signals are used by the patient block interface circuit, 1 to clock the data (the data counter), and 1 to measure the length of the interbyte gap (the gap counter). The first clock, FE-CLOCK, is from the patient block assembly. FE-CLOCK clocks the data counter which counts 8 bits of data going into the patient block interface circuit.

When the data counter reaches 8, FE-READY to the 68000 microcomputer circuit goes high. Note that the data is not latched yet by the 68000 microcomputer circuit. A falling FE-READY causes the data to be latched. Each time FE-CLOCK goes low the gap counter is cleared. After the byte of data has been transmitted by the patient block assembly, FE-CLOCK is idled high.

The phase 2 clock counts the length of the interbyte gap.



While FE-CLOCK is idled high, the gap counter is no longer being cleared. The other clock signal, E from the 68000 microcomputer circuit, clocks the gap counter. When the gap counter reaches 4, an interbyte gap has occurred. When the interbyte gap is detected, the gap counter causes FE-READY (front end ready) to the 68000 microcomputer circuit to go low. This indicates to the 68000 microcomputer circuit that the patient block interface circuit has received a byte of data from the patient block assembly. Upon receiving FE-READY, the 68000 microcomputer circuit latches the data from the front end interface circuit on bus Q0–Q7.

FE-ASYNC is used to transmit commands to the patient block assembly.

FE-ASYNC (front end asynchronous) is used by the 68000 microcomputer circuit to transmit asynchronous command data to the patient block assembly through the patient block interface circuit. Typical commands initialize the patient block assembly, and change sampling rate and gain. FE-ASYNC is idled high when no commands are being transmitted to the patient block assembly.

RESET* clears the patient block interface circuit and powers down the patient block assembly.

The RESET* signal is applied to the patient block interface circuit when the 68000 microprocessor executes a reset instruction. RESET* clears ECG data in a serial-to-parallel register and is gated to remove power from the patient block assembly.

68000/65C02 microcomputer circuit communication link

The 68000/65C02 microcomputer communication link is described following the 65C02 microcomputer circuit description.

Theory of Operation (Cont)

65C02 Microcomputer Circuit

The 65C02 microcomputer circuit performs many support functions for the 68000 microcomputer circuit. The 65C02 microcomputer circuit:

- stores setup information, such as normal operating voltages and currents, for comparison with actual monitored values,
- controls the generation of analog outputs, which control the intelligent lcd, speaker, thermal paper drive motor, and thermal print head,
- controls thermal paper drive motor current draw and tachometer, and battery,
- controls the keyboard interface, and
- communicates with the 68000 microcomputer circuit.

Setup information is stored in a serial EEPROM.

Setup information is stored in a serial EEPROM in the 65C02 microcomputer circuit. The data stored there includes thermal print head voltage, battery gauge, normal and abnormal (paper out or writer door open) thermal paper drive motor currents, etc. This information cannot be lost when the unit loses power.

Dual-Function Signals

MUX0 and MUX1 (multiplex 0 and multiplex 1) are 2 dual-function signals generated by the 65C02 microcomputer circuit for the I/O circuit. When the 65C02 microprocessor is generating analog outputs, MUX0 and MUX1 select the input to be gated to the output of a demultiplexer.

When the 65C02 microprocessor is either generating or reading lcd displays, MUX0 and MUX1 are used as read/write* and register select signals, respectively. (The 65C02 microprocessor reads an lcd display when the unit times out. When a key is pressed, the display that was previously read is displayed.) Finally, when the 65C02 microprocessor is monitoring parameters through the I/O circuit, MUX0 and MUX1 are used to gate 1 of the inputs of a multiplexer to the output.

Theory of Operation (Cont)

65C02 Microcomputer Circuit (Cont)

Analog Outputs

Analog outputs are generated by applying digital data to a dac in the I/O circuit and demultiplexing the dac output.

Analog outputs from the processor pcb assembly adjust the lcd viewing angle, and control the thermal paper drive motor and thermal print head. (The actual signal generation for many of the analog output functions is done in the I/O circuit. For more detail, refer to the I/O circuit description of this block diagram theory in this chapter.) Digital control data, to be converted to analog, is applied to the I/O circuit by the 65C02 microcomputer circuit on BUS0–BUS7.

The 65C02 microprocessor sets DAC-WR* (digital-to-analog converter write*) low, loading the data from BUS0–BUS7 into a dac within the I/O circuit. The 65C02 microcomputer circuit next applies MUX0 (multiplex 0), MUX1 (multiplex 1), and OUT-MUX* (output multiplexer*) to a demultiplexer in the I/O circuit. MUX0 and MUX1 select the output to which the analog data is output. OUT-MUX* enables the output of the demultiplexer.

The output of a VIA is used to generate audible tones.

To generate an audible speaker tone, the 65C02 microprocessor applies a square wave signal through a VIA on BEEP to the I/O circuit. BEEP is inverted by the I/O circuit and used for the ground connection for the speaker which is powered by VBATT from the power supply circuit. The inverted BEEP signal is applied to the ground of the speaker since the inverter can sink much current, but cannot source enough current to drive the speaker.

LCD Signals

LCD-EN (liquid crystal display enable) is applied to the I/O circuit by the 65C02 microcomputer circuit to enable the lcd. The lcd uses MUX0 and MUX1 as read/write* and register select control signals, respectively. BUS0–BUS7 carry lcd data from the 65C02 microcomputer circuit to the I/O circuit.

Analog Inputs

The 65C02 microcomputer circuit monitors several parameters in the MAC PC electrocardiograph.

The 65C02 microcomputer circuit, along with the I/O circuit, monitors several parameters in the unit. Monitored are several battery voltage levels, charger voltage, and thermal paper drive motor current draw. These are applied to a multiplexer within the I/O circuit. The 65C02 microcomputer circuit uses MUX0 (multiplex 0), MUX1 (multiplex 1), and MUX2 (multiplex 2) to select the input channel to be gated through the multiplexer as HI/LO* (high/low*).

The VIA can only detect logic transitions not stable logic levels.

In the 65C02 microcomputer circuit, HI/LO* is applied to an interrupt input to VIA. The VIA interrupt input can only detect edges not logic levels. Therefore, an additional signal is used by the 65C02 microprocessor to determine the logic level of HI/LO*.

Theory of Operation (Cont)

65C02 Microcomputer Circuit (Cont)

Analog Inputs (Cont)

The 65C02 microprocessor determines the level of HI/LO* by forcing HI/LO* to toggle.

To determine the state of HI/LO*, the 65C02 microcomputer circuit toggles IN-MUX* (input multiplexer*). If HI/LO* is high, toggling IN-MUX* causes HI/LO* to follow IN-MUX*. The VIA detects the HI/LO* transition and sets an interrupt bit, indicating to the 65C02 microprocessor that HI/LO* was high. If HI/LO* is low, then toggling IN-MUX* has no effect, since the toggling IN-MUX* is blocked by a diode. The absence of an interrupt flag indicates that HI/LO* was low.

Reading the keyboard

The keyboard is arranged as a 6 column by 8 row matrix of switches. Drive data for the 6 columns is applied by the 65C02 microcomputer circuit to BUS0–BUS5. Depressed switches (keys) are sensed by the 65C02 microcomputer circuit on KSENSE0*–KSENSE7*.

Thermal Writer Signals

The thermal writer assembly uses a dc thermal paper drive motor.

The thermal paper drive motor used in the thermal writer assembly is a dc motor, not a stepper motor (which is normally used in such applications). Since a dc motor is used, the speed of the motor is dependent upon the voltage applied to the motor. Therefore, fine control of the motor voltage must be maintained.

The 65C02 microcomputer circuit controls the thermal paper drive motor using position feedback from an optical tachometer.

The thermal paper drive motor uses an optical tachometer to provide feedback of motor position. TACH-OUT (tachometer output) is pulsed 6400 times per revolution of the thermal paper drive motor shaft. The 65C02 microcomputer circuit counts the pulses, and compares the actual motor position with the desired position. If the motor speed needs changing, the 65C02 microcomputer circuit changes the voltage applied to the motor.

Real-Time Clock

When the unit is powered up, the 65C02 microcomputer circuit monitors the real-time clock.

The RTC (real-time clock) signal toggles every time 128-SEC (128 second) from the clock circuit goes high (once every 128 seconds). When the 65C02 microcomputer circuit is powered up, it periodically reads RTC through the I/O circuit. If the state of RTC has changed since the last time it was read, then the time/date must be updated.

When the unit is off, every 128 seconds the clock circuit wakes up the 65C02 microcomputer circuit.

When the unit is off, the clock circuit still generates 128-SEC every 128 seconds so that the 65C02 microcomputer circuit can update the real-time clock. 128-SEC is applied to the power supply circuit which powers up the 65C02 microcomputer circuit. When the 65C02 microcomputer circuit powers up, it determines that the high 128-SEC "woke" it up. It then executes its clock/calendar program.

The 65C02 microcomputer circuit executes its clock/calendar program to update the time and date in memory. When 128-SEC goes high, it causes RTC to toggle. The 65C02 microcomputer circuit reads RTC and determines whether or not the state of RTC has changed. If so, the 65C02 microcomputer circuit updates the time and date in memory.

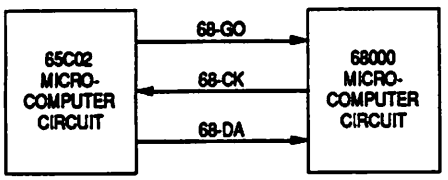
Theory of Operation (Cont)

68000/65C02 Microcomputer Circuit Communication

The 68000/65C02 microcomputer communication link is used to communicate keyboard, lcd, and thermal paper drive motor information between the 68000 microcomputer circuit and the 65C02 microcomputer circuit. Communication in both directions (65C02 microcomputer circuit-to-68000 microcomputer circuit and vice versa) is initiated by the 65C02 microcomputer circuit, with the 68000 microcomputer circuit handling the clocking of data into or out of the 68000 microcomputer circuit.

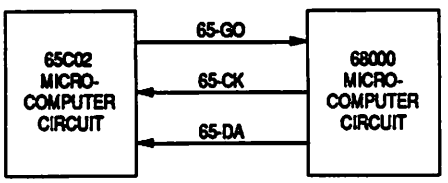
65C02-to-68000 microcomputer circuit communication

When the 65C02 microcomputer circuit has a byte of information to transmit to the 68000 microcomputer circuit, it momentarily (not long enough to generate a level 4 interrupt to the 68000) drops 68-GO (68000 go) low. The 68000 microcomputer circuit periodically checks for a low 68-GO. Upon detecting the low 68-GO, the 68000 microcomputer circuit toggles 68-CK (68000 clock) 8 times, shifting the byte from the 65C02 microcomputer circuit into the 68000 microcomputer circuit on 68-DA (68000 data).



68000-to-65C02 microcomputer circuit communication

When the 65C02 microcomputer circuit is ready to receive a byte of data from the 68000 microcomputer circuit, it momentarily (not long enough to reset the 68000) drops 65-GO (65C02 go) low. This indicates that the 65C02 microcomputer circuit is ready to accept a byte of information from the 68000 microcomputer circuit. The 68000 microcomputer circuit periodically checks for a low 65-GO. Upon detecting a low 65-GO, the 68000 microcomputer circuit clocks the byte into the 65C02 microcomputer circuit on 65-DA (65C02 data) by toggling 65-CK (65C02 clock) 8 times.



Theory of Operation (Cont)

Power Supply Circuit

The power supply circuit controls power to the various circuits on the processor pcb assembly. Many power signals are used, because not all devices receive power at the same time. Devices (circuits) that are not being used are powered down to conserve power stored in the batteries. Note that power is removed from unused circuits regardless of whether or not the power module is connected, leaving more power available to charge the batteries.

Where does power come from?

All power comes from either a power module (if 1 is connected to the unit) or the battery pack. The MAC PC electrocardiograph power module supplies power on DC-V (dc voltage) and DC-GND (dc ground). The battery pack supplies power on BATT-HI (battery high) with BATT-LO (battery low) the ground.

Power Module

The power module must maintain a minimum output of 27 V dc at 150 milliamps on DC-V (referenced to DC-GND) to charge the batteries. The 65C02 microcomputer circuit, through the I/O circuit, detects a voltage on CHRG-V (charger voltage). It then sets CHRG-DIS (charge-discharge) low which allows the battery to be charged by BATT-HI and BATT-LO.

Battery Pack

The battery pack consists of sixteen 1.25-volt (nominal) rechargeable nickel-cadmium cells connected in series. These cells are charged by BATT-HI and BATT-LO from the power supply circuit. When all 16 cells are fully charged, the voltage across the battery pack (BATT-HI referenced to BATT-LO) should be approximately 21.3 volts.

Regulator U53 regulates power from the power module.

The power supply circuit applies several signals, U53 IN, U53 ADJ, U53 CTRL, and U53 GND, to regulator U53. Regulator U53 receives special mention here because it functions as a part of the thermal print head interface circuit but is physically located elsewhere. On processor pcb assembly versions -001, -003, and -004, U53 is located on the thermal writer assembly which acts as a heatsink.

On version -002, it is mounted on the connector pcb assembly, pn 85696-XXX. Regulator U53 attempts to return a constant 120 milliamp output, U53 OUT, back to the power supply circuit. This regulated signal eventually becomes VBATT which is the source of power for the various power signals.

Continuous Power

The 5V-C (5-volts continuous) signal is a continuous 5-volt power supply signal. 5V-C powers a counter in the clock circuit which is continually dividing the output of a crystal to generate the real-time clock signal (RTC).

Theory of Operation (Cont)

Power Supply Circuit (Cont)

The 5V-C power signal also supplies continuous power to the dynamic RAM and refresh logic devices in the 68000 microcomputer circuit. (The first version of the processor pcb assembly, pn 85599-001, called this signal 5V-D.) This becomes important when the 68000 microprocessor is halted, reset, or powered down by the 65C02 microcomputer circuit. The 68000 microprocessor cannot refresh the dynamic RAM if it is halted, reset, or powered down, so continuous power is needed for external logic to refresh the dynamic RAM.

Interruptible 65C02 microcomputer circuit power

The interruptible 5V-A signal supplies power to the 65C02 microcomputer circuit. It also powers parts of the clock and I/O circuits controlling the 65C02 microcomputer circuit's timing and analog outputs.

What causes 5V-A power to go on?

5V-A power is applied by the power supply circuit in response to any of 3 things: the rising edge of ON-OFF (caused by pressing the ON/OFF switch on the keyboard), the rising edge of 128-SEC (128 seconds) from the clock circuit, or the rising edge of W-DOG (watchdog) from the 65C02 microcomputer circuit. The rising edge of these signals triggers a one-shot within the power supply circuit, taking 5V-A to 5 volts.

If the unit was turned on, power is applied to the 68000 microcomputer circuit.

When the ON/OFF key is pressed, the ON-OFF signal causes 5V-A to be taken to 5 volts. 5V-A, in turn, powers the 65C02 microcomputer circuit. The 65C02 microprocessor checks to see if the ON/OFF switch was pressed. In this case, it was. The 65C02 microcomputer circuit sets 68K-PWR* low, taking 5V-B to 5 volts. The 68000 microcomputer circuit, powered by 5V-B, then executes a dynamic RAM refresh routine, and waits for a level 4 interrupt from the 65C02 microcomputer circuit to start its normal operating software.

If the unit was not turned on, the clock/calendar program is executed.

When the unit is off, power is applied to 5V-A every 128 seconds. This happens in response to a high 128-SEC from the clock circuit. Since 5V-A powers the 65C02 microcomputer circuit, the 65C02 microcomputer circuit is powered up. When the 65C02 microcomputer circuit determines that 128-SEC "woke" it up, it executes its clock/calendar program.

The 65C02 microcomputer circuit executes its clock/calendar program to update the time and date in memory. When 128-SEC goes high, it causes RTC to toggle. The 65C02 microcomputer circuit reads RTC and determines whether or not the state of RTC has changed. If so, the 65C02 microcomputer circuit updates the time and date in memory.

The 65C02 microprocessor must reset the watchdog, or power will be removed from 5V-A.

After being powered up by 5V-A, the 65C02 microcomputer circuit must generate high W-DOG pulses, which reset the one-shot in the power supply circuit, to keep power applied to the 65C02 microcomputer circuit. As long as the 65C02 microcomputer circuit generates W-DOG pulses more often than every 31 milliseconds (from $2/3*RC = 2/3 * 100k\Omega * 0.47\mu F$), the power supply circuit one-shot is reset, and 5V-A remains powered.

Theory of Operation (Cont)

Power Supply Circuit (Cont)

Any time the 65C02 microprocessor is not performing a function, it can stop generating W-DOG signals for the power supply circuit. This allows the one-shot in the power supply circuit to time out, removing power from 5V-A and therefore powering down the 65C02 microcomputer circuit. In other words, the 65C02 microcomputer circuit generates W-DOG signals to keep itself turned on, and turns itself off by not generating W-DOG signals.

A short delay upon powerup allows stabilization of 5V-A and a clock circuit oscillator.

To allow time for the stabilization of 5V-A and a clock circuit oscillator upon powerup, the power supply circuit generates a slightly delayed reset signal, A-RESET*. A-RESET* is applied to the 65C02 microcomputer circuit, holding it reset for a short time after powerup. A-RESET* then goes high, allowing the 65C02 microcomputer circuit to operate. A-RESET* is also applied to the 68000 microcomputer circuit to hold the external dynamic RAM refresh logic in the refresh mode. This is necessary because the 68000 microprocessor is powered down when the 65C02 microcomputer circuit is reset.

A threshold voltage is generated for use by various comparators.

V-THRESH (threshold voltage) is a reference voltage that is applied to comparators in the 68000 microcomputer, patient block interface, and thermal print head interface circuits. V-THRESH is generated by dividing 5V-A and should be approximately 1.5 volts.

Interruptible 68000 microcomputer circuit and patient block interface circuit power

The interruptible 5V-B signal supplies power to the 68000 microcomputer circuit and the patient block interface circuit. (Both of these circuits need to be powered simultaneously, since 1 of the functions of the 68000 microcomputer circuit is to acquire data from the patient block assembly.) 5V-B is controlled by the 65C02 microcomputer circuit by 68K-PWR* (68000 power). When the 65C02 microcomputer circuit sets 68K-PWR* low, 5V-B is taken to 5 volts.

Interruptible thermal print head interface circuit and I/O circuit power is controlled by the presence or absence of a voltage on the thermal print head.

The interruptible 5V-H signal supplies power to the thermal print head control circuit and a part of the I/O circuit which powers the motor tachometer LED on the thermal paper drive motor. 5V-H is generated by gating 5V-C under control of H-VHD (thermal print head voltage) from the thermal print head interface circuit. H-VHD is the analog thermal print head voltage (which varies from thermal print head to thermal print head) controlled by the 65C02 microcomputer circuit. When H-VHD reaches about 3 volts or greater, the power supply circuit takes 5V-H to 5 volts.

I/O circuit, patient block interface circuit, and thermal print head interface circuit power

VBATT-S (switched battery voltage) supplies power to the I/O circuit, patient block interface circuit, and the part of the thermal print head interface circuit which regulates thermal print head power. VBATT-S is controlled by the 65C02 microcomputer circuit through S-PWR* (switched power*). To apply power to VBATT-S, the 65C02 microcomputer circuit sets S-PWR* low.

Theory of Operation (Cont)

Clock Circuit

The clock circuit uses a 16-MHz oscillator and a 32.768-kHz crystal to provide timing signals to both the 68000 and 65C02 microcomputer circuits. The 16-MHz oscillator is divided to generate the 8-MHz 68K-CLK (68000 clock) and 6502-CLK (65C02 clock) signals. The output of the 32.768-kHz crystal is REF-CLK (refresh clock) for the 68000 microcomputer circuit.

The crystal output is also divided to generate 128-SEC and RTC. When power is off, 128-SEC is applied to the power supply circuit every 128 seconds to "wake up" the 65C02 microprocessor. The 65C02 microcomputer circuit reads RTC through the I/O circuit. If the state of RTC has changed since the last time it was read, then the time is updated in memory. When power is on, the 65C02 microcomputer circuit periodically reads RTC to determine whether or not the time and date stored in memory need updating.

Outputs

A 16-MHz oscillator provides timing for the 68000 and 65C02 microcomputer circuits.

68K-CLK is generated by dividing the output of the 16-MHz oscillator by 2. 68K-CLK is used to clock the 68000 microprocessor. It also is used to generate thermal print head interface circuit and thermal print head timing. 6502-CLK is a 2-MHz square wave signal generated by further dividing the output of the 16-MHz oscillator. It is applied to the clock input of the 65C02 microprocessor in the 65C02 microcomputer circuit.

A 32.768-kHz crystal provides timing for dynamic RAM external refresh logic and the real-time clock.

REF-CLK is a 32.768-kHz square wave taken directly from a crystal. It is used by external logic in the 68000 microcomputer circuit to refresh the dynamic RAM after the 65C02 microcomputer circuit removes power from the 68000 microprocessor. RTC is generated by further dividing the output of the 32.768-kHz crystal. It is a square wave signal that toggles once every 128 seconds, giving RTC a period of 256 seconds. The 65C02 microprocessor uses the fact that RTC toggled to update the time stored in memory.

The clock circuit causes the power supply circuit to take 5V-A to 5 volts every 128 seconds.

The 128-SEC signal is a square wave with a period of 128 seconds. It causes RTC to toggle, and is applied to the power supply circuit to take 5V-A to 5 volts. 5V-A supplies power to the 16-MHz oscillator and to the 65C02 microprocessor in the 65C02 microcomputer circuit. When 5V-A comes up, the 65C02 microprocessor "wakes up." The 65C02 microprocessor then executes the clock/calendar program to update the time/date data stored in memory. If the state of RTC changed since the last time it was read, then the time and date are updated in memory. Note that while the MAC PC electrocardiograph is powered up, the 65C02 microprocessor still updates the time and date stored in memory.

Inputs

The clock circuit uses 2 inputs from the power supply circuit.

The clock circuit has 2 inputs, 5V-A and 5V-C, both from the power supply circuit. 5V-C is a continuous 5-volt supply which powers a counter in the clock circuit. The counter divides the 32.768-kHz crystal output to generate 128-SEC. 5V-A supplies power to the 16-MHz oscillator in the clock circuit.

Theory of Operation (Cont)

Patient Block Interface Circuit

Leadwires from the patient plug into a patient block assembly (acquisition module). The patient block assembly receives ECG data from the patient through the leadwires, amplifies and filters the data, and then transmits the data to the processor pcb assembly. The patient block interface circuit provides an interface between the patient block assembly and the 68000 microcomputer circuit and power supply circuits. Included are power, timing, and data signals.

Two signals control power to the patient block assembly.

To supply power for the patient block assembly, the patient block interface circuit regulates VBATT-S (switched battery voltage) and applies the regulated voltage to the patient block assembly as FE-VCC (front end power). FE-ASYNC (front end asynchronous, so named because this signal carries asynchronous command information from the 68000 microcomputer circuit to the patient block interface circuit) and RESET* are used along with V-THRESH from the power supply circuit to control the regulation of power for the patient block assembly.

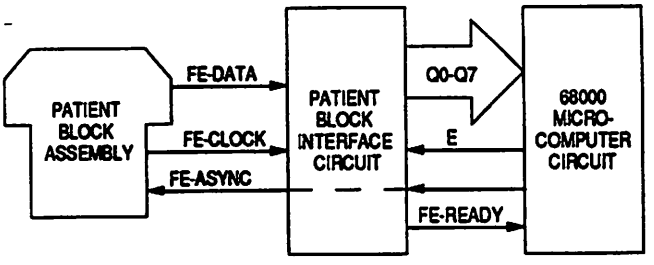
When the patient block assembly is not needed, the 68000 microcomputer circuit removes power from it by holding FE-ASYNC low for more than 30 milliseconds. Power is also removed from the patient block assembly when RESET* goes low.

Regulator U51 regulates power being applied to the patient block assembly.

The patient block interface circuit applies several signals, U51 IN, U51 ADJ, U51 CTRL, and U51 GND, to regulator U51. (Regulator U51 receives special mention here because it functions as a part of the thermal print head interface circuit but is physically located elsewhere. On processor pcb assembly versions -001, -003, and -004, U51 is located on the thermal writer assembly which acts as a heatsink. On version -002, it is mounted on the connector pcb assembly, pn 85696-XXX.) The output of regulator U51, U51 OUT, returns 14.2 volts (measured on FE-VCC) with the patient block assembly disconnected.

Patient block assembly-to-unit data transfers

Two signals are used to derive timing for data transfers from the patient block assembly to the processor pcb assembly: E (phase 2 clock) from the 68000 microcomputer circuit and FE-CLOCK (front end clock) from the patient block assembly. FE-CLOCK is a 1-MHz square wave. It is used by the patient block interface circuit to clock ECG data on FE-DATA into a serial-in, parallel-out shift register in the patient block interface circuit.



Theory of Operation (Cont)

Patient Block Interface Circuit (Cont)

When 8 bits of data have been clocked into the patient block interface circuit, FE-READY (front end ready) goes high, and FE-CLOCK is idled high by the patient block assembly. The patient block interface circuit then uses E from the 68000 microcomputer circuit to cause FE-READY to go low. The low FE-READY synchronizes the transfer of parallel data into the 68000 microcomputer circuit on Q0–Q7.

Commands are transmitted from the unit to the patient block assembly.

Asynchronous commands are sent from the processor pcb assembly to the patient block assembly on FE-ASYNC. Commands are used to change the sampling rate and gain, among other things. The 68000 microcomputer circuit applies the asynchronous command information to the patient block interface circuit which passes it unchanged to the patient block assembly.

In the patient block assembly, the serial stream is converted to parallel. The command is then decoded and executed. FE-ASYNC is idled high when no commands are being sent to the patient block assembly. While FE-ASYNC is high, power is applied to the patient block assembly. If the patient block assembly is no longer needed FE-ASYNC is held low causing power to be removed.

Thermal Print Head Interface Circuit

The thermal print head interface circuit receives waveform and textual data to be printed from the 68000 microcomputer circuit along with control and clock signals. It uses these signals to generate the appropriate controlling signals for the thermal print head. The thermal print head interface circuit applies thermal print head voltage feedback to the power supply circuit.

Power

Three signals control power to thermal print head.

Power for the thermal print head is derived under control of HEAD-V (head voltage) from the I/O circuit, H-BURN* (load/burn* strobe) from the 68000 microcomputer circuit, and V-THRESH (threshold voltage) from the power supply circuit. Under normal operation, HEAD-V is a 0- through 5-volt analog signal which is multiplied by 4 in the thermal print head interface circuit.

This 0- through 20-volt analog signal is used to gate VBATT from the power supply circuit to form H-VHD (head voltage). H-VHD is applied to the thermal print head and is also fed back to the power supply circuit. In the power supply circuit, it is used in controlling 5V-H. 5V-H supplies power to the logic devices in the thermal print head interface circuit.

The thermal print head needs 5 volts to power logic devices.

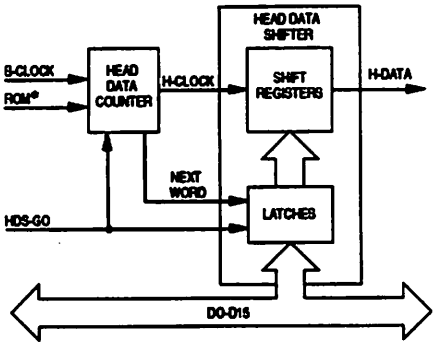
5V-H from the power supply circuit is applied to the thermal print head as H-VCC, as is a digital ground signal, H-GND. The thermal print head needs 5 volts to power data shifters and latches.

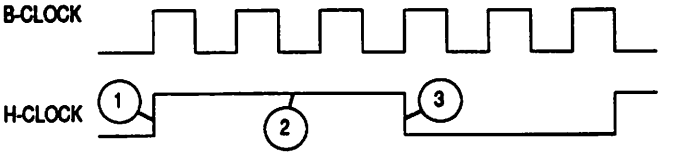
Theory of Operation (Cont)

Thermal Print Head Interface Circuit (Cont)

Thermal print head timing is controlled by B-CLOCK from the 68000 microcomputer circuit.

A counter in the thermal print head interface circuit, referred to as the head data counter, divides B-CLOCK from the 68000 microcomputer circuit to generate the 2-MHz clock signal H-CLOCK. The rising edge of H-CLOCK shifts data out of the head data shifter on H-DATA. H-DATA is buffered to form H-DI (head data in). The falling edge of H-CLOCK is applied to the thermal print head as H-CK (head clock), where it clocks data on H-DI into the thermal print head.





1. DATA IS SHIFTED OUT OF THE HEAD DATA SHIFTER ON THE *RISING* EDGE OF H-CLOCK.
2. TRANSMISSION TIME FOR DATA TO REACH THERMAL PRINT HEAD.
3. DATA SHIFTED INTO THE THERMAL PRINT HEAD ON THE *FALLING* EDGE OF H-CLOCK.

Parallel thermal print head data is converted to a serial stream by the head data shifter.

Waveform and text data are applied in a long word write operation to the thermal print head interface circuit by the 68000 microcomputer circuit on data bus D0–D15. When the first word of valid data is on D0–D15, the HDS-GO (head data shifter go) from the 68000 microcomputer circuit is taken high. This signal is applied to 2 parallel-load shift registers in the thermal print head interface circuit referred to as the "head data shifter."

The positive edge of HDS-GO causes the head data shifter to latch the parallel data from D0–D15. It also clears the head data counter, disabling the head data counter from shifting the data until the second word of data arrives from the 68000 microcomputer circuit. (The devices used for the head data counter have input capacitance on their clear inputs, causing the head data counter to remain cleared after HDS-GO is removed.)

The 68000 writes the second word to the head data shifter which begins shifting data.

Next, the 68000 microcomputer circuit applies the second word of data to data bus D0–D15. Again, the 68000 microcomputer circuit sets HDS-GO high. The thermal print head interface circuit head data shifter uses HDS-GO to clock the byte of data currently in latches to shift registers and to latch the second word of data from D0–D15. The 68000 microcomputer circuit then accesses its EPROM (internal to the 68000 microcomputer circuit) which sets ROM* (read-only memory*) low. ROM* is used to enable the head data counter which shifts the serial thermal print head data to the thermal print head.

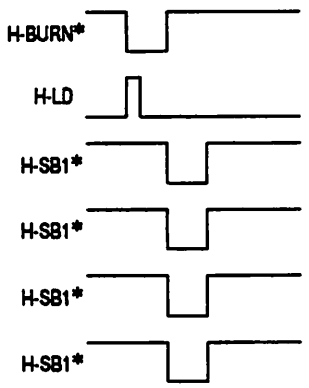
Theory of Operation (Cont)

Thermal Print Head Interface Circuit (Cont)

The second word of data is clocked into the head data shifter shift registers.

After the first word of data has been shifted to the thermal print head, NEXT WORD from the head data counter goes high. The rising edge of NEXT WORD causes the second word of data to be clocked from the latch portion of the head data shifter to the shift register portion. This word is then shifted to the thermal print head on H-DATA.

Thermal print head load and burn signals turn on the elements of the thermal print head.



Load and burn signals for the thermal print head are derived from H-BURN* (load/burn* strobe) from the 68000 microcomputer circuit. H-LD (head load) is a positive-going pulse of at least 1.1 µs wide which occurs when H-BURN* goes low (approximately every 2 milliseconds). H-LD clocks the data that was previously shifted into the thermal print head shift registers on H-DI from the latch inputs to their outputs.

Identical head strobe signals H-SB1* through H-SB4* are slightly delayed equivalents of H-BURN*. The delay ensures that data has been loaded into the thermal print head before the head strobes occur. H-SB1* through H-SB4* gate the latch outputs to enable drive transistors. These drive transistors, depending upon the data being applied, turn on allowing current to flow through resistive elements and "burning" the coating on the thermal paper.

Thermal print head burnout protection

H-BURN* and V-THRESH are also used to disable the thermal print head to prevent burn out. Normally, H-BURN* is low for about 1 ms (to allow the data to burn the coating on the thermal paper) then high for 1 ms. If H-BURN* should remain low for too long (ie, more than approximately 50 milliseconds), the thermal print head would burn out.

To prevent this, the thermal print head circuit compares H-BURN* to V-THRESH. When H-BURN* is high, an RC timing circuit is charged. When H-BURN* goes low, the capacitor slowly discharges. If the voltage across the capacitor becomes less than V-THRESH (which takes approximately 50 milliseconds), the comparator output goes to 0. HEAD-V is therefore shorted to ground, disabling the thermal print head.

Theory of Operation (Cont)

I/O Circuit

The I/O circuit:

- generates analog outputs which control the lcd viewing angle, thermal paper drive motor voltage, and thermal print head voltage,
- monitors thermal paper drive motor current draw and tachometer, and battery charge,
- interfaces with the keyboard and lcd, and
- drives the speaker.

Analog Outputs

Analog outputs are generated by a dac and demultiplexer.

The analog outputs are generated by a dac in the I/O circuit. The dac receives digital data from the 65C02 microcomputer circuit on BUS0–BUS7. The data is clocked into the dac by DAC-WR* (dac write enable*) from the 65C02 microcomputer circuit. The dac output is applied to an analog demultiplexer which is controlled by OUT-MUX* (output multiplexer*) from the 65C02 microcomputer circuit. The demultiplexer gates analog signals controlling the lcd viewing angle, thermal paper drive motor, and thermal print head voltages.

The user can adjust the lcd viewing angle to personal preferences.

The viewing angle of the lcd may be changed, under user preference, to allow the lcd to be read more easily at greater angles from perpendicular. LCD-VEE (lcd viewing angle voltage), a buffered version of the demultiplexer output, is applied to the display assembly to adjust the viewing angle of the lcd. The larger LCD-VEE is, the smaller the viewing angle.

Controlling the thermal paper drive motor

The thermal paper drive motor control voltage output, from the dac through the analog demultiplexer, controls the MOTOR-HI (thermal paper drive motor voltage) signal. MOTOR HI drives the thermal paper drive motor. MOTOR-LO is the ground path from the thermal paper drive motor.

Audible tones

The speaker is controlled by a square wave signal on BEEP from the 65C02 microcomputer circuit. The I/O circuit inverts BEEP, forming BEEP* which is applied to the speaker.

Theory of Operation (Cont)

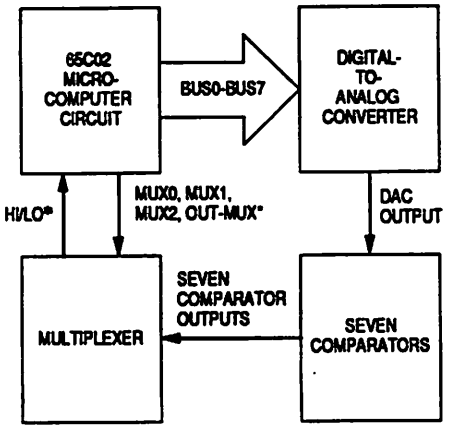
I/O Circuit (Cont)

Analog Inputs

Parameters are monitored using a successive approximation method.

The I/O circuit monitors thermal paper drive motor current draw and battery charge through a series of comparators on the inputs of an analog multiplexer. To determine the value of 1 of the parameters, the 65C02 microcomputer circuit uses a successive approximation method.

It first applies a digital approximation to BUS0–BUS7 which is converted to an analog voltage by a dac in the I/O circuit. The dac applies the analog voltage to all comparators which compare the analog voltage with the actual value for their appropriate parameter. The comparator outputs are applied to an analog multiplexer.



The 65C02 microcomputer circuit selects the comparator output to be monitored using MUX0 and MUX1. The HI/LO* (high/low*) signal is the analog multiplexer output containing the result of the approximation. HI/LO* is applied to the 65C02 microcomputer circuit.

The 65C02 microcomputer circuit makes repeated approximations to determine the value of a single parameter. After each approximation, the I/O circuit returns a "too low" or "too high" answer (through HI/LO*). The 65C02 microcomputer circuit adjusts its approximation according to HI/LO*, and the process repeats until the actual value is determined.

An input multiplexer is used to select one of the comparator outputs.

IN-MUX* (input multiplexer*) is toggled by the 65C02 microcomputer circuit to force HI/LO* to toggle. This is necessary because the VIA input used, part of the 65C02 microcomputer circuit, can only detect logic transitions not stable logic levels. If HI/LO* was high, it toggles along with IN-MUX*. If HI-LO* was low, it remains low, as the rising edge of IN-MUX* is blocked by a diode. The leading edge of HI/LO* sets an interrupt bit within the VIA, indicating to the 65C02 microprocessor that the initial approximation was too low.

Monitoring the battery

Battery taps, TAP1, TAP2, TAP3, and TAP4, are provided to monitor 4, 8, 12, and all 16 battery cells, respectively. TAP1, TAP2, and TAP3 should correspond to 1/4, 1/2, and 3/4 of a full battery charge (5.3 V, 10.6 V, and 16.0 V, respectively). TAP4 is the total battery pack voltage divided by 5 and should be about 4.3 V. All 4 battery tap signals, after comparison to the 65C02 microprocessor's approximation, are applied to the comparators.

Monitoring the power module charging voltage

The power supply circuit applies CHRG-V (charger voltage) to the I/O circuit, where it is applied along with the 65C02 microprocessor's approximation, to a comparator. CHRG-V is the voltage of the power module divided by 7. Division by 7 is necessary so that CHRG-V is within the input voltage limits of the comparator.

Theory of Operation (Cont)

I/O Circuit (Cont)

Analog Inputs (Cont)

Monitoring the switched battery voltage

VBATT-S (switched battery voltage) from the power supply circuit is the regulated, switched voltage of the battery. VBATT-S differs from CHRG-V in that CHRG-V is directly from the power module, and VBATT-S is regulated and turned on and off under control of S-PWR* from the 65C02 microcomputer circuit. In the I/O circuit, VBATT-S is divided by 5 so that the voltage is within the input voltage limits of a comparator. The comparator output is applied to the input multiplexer for sampling by the 65C02 microcomputer circuit.

Monitoring thermal paper drive motor current

Thermal paper drive motor current draw is sensed through a resistor in the I/O circuit. The current through the resistor generates a voltage across the resistor. This voltage is applied to 1 of the comparators on the multiplexer inputs. The 65C02 microcomputer circuit compares the motor current with current limits stored in the serial EEPROM in the 65C02 microcomputer circuit.

If the thermal paper runs out, the motor current (and the voltage across the current sense resistor) goes above the upper limit. This is because the drive roller directly contacts the thermal print head causing more drag on the thermal paper drive motor. If the thermal writer door is left open, there is almost no drag on the motor. The motor current (and the voltage across the current sense resistor) then goes below the lower limit.

Monitoring the real-time clock

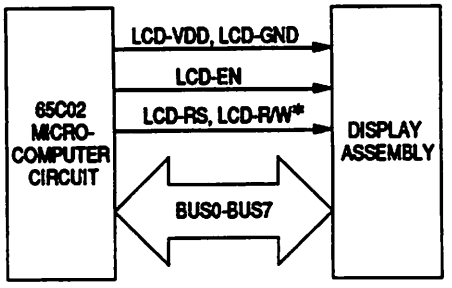
The RTC (real-time clock) signal is applied directly to 1 of multiplexer inputs. Since RTC is digital, it does not need to be compared to an analog approximation from the dac. Transitions in RTC are sensed by the VIA in the 65C02 microcomputer circuit. When the state of RTC changes, the 65C02 microcomputer circuit updates the time and date in memory.

Theory of Operation (Cont)

I/O Circuit (Cont)

The I/O circuit also interfaces the 65C02 microcomputer circuit to the display assembly, keyboard assembly, thermal paper drive motor, and speaker.

Display Assembly Signals



The 65C02 microcomputer circuit communicates with the display assembly through the I/O circuit. The lcd in the display assembly contains its own microprocessor, so the 65C02 microprocessor can write high-level commands to it. Also, because the display has a small amount of memory, the 65C02 microprocessor can read data from the display when the display times out or goes blank. (The display times out to save power.) This data is then displayed when the user presses a key on the keyboard.

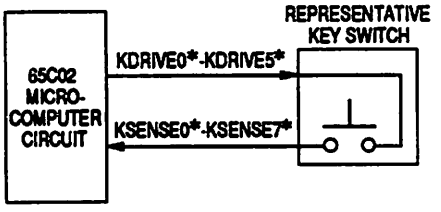
LCD-EN (lcd enable) enables the data transaction, either into or out of the lcd. LCD-RS (lcd register select) indicates to the lcd that the data on BUS0–BUS7 is data (when high) or an instruction (when low). LCD-R/W* (lcd read/write*) is used by the 65C02 microcomputer circuit when reading data from the lcd (LCD-R/W* is high) or when writing an instruction or data to the lcd (LCD-R/W* is low). LCD-VDD powers the lcd in the display assembly, and LCD-GND is a logic ground for the lcd.

Keyboard Signals

The keyboard is arranged electrically in a 6 column-by-8 row matrix.

The keys on the keyboard assembly are electrically arranged in a 6 column by 8 row matrix. Each key is basically a switch between a column (drive) signal and row (sense) signal. When a key is depressed, it makes a short circuit from the column that the key is in (in the electrical matrix) to the row the key is in.

To detect a key depression, each drive signal is taken low, and all sense signals are sampled.



To detect a key depression, the I/O circuit buffers and inverts BUS0–BUS5 from the 65C02 microcomputer circuit to create KDRIVE0*–KDRIVE5* which drive the 6 columns in the keyboard assembly low. Only 1 of the keyboard drive signals is low at any time. By scanning KSENSE0*–KSENSE7* for a low signal, 65C02 microcomputer circuit can determine which key was depressed. Note that the KSENSE0*–KSENSE7* inputs to the VIA in the 65C02 microcomputer circuit are high when idle.

Theory of Operation (Cont)

I/O Circuit (Cont)

Thermal Paper Drive Motor

The thermal writer uses a dc motor to drive thermal paper.

The thermal writer assembly uses a dc motor, not a stepper motor that is more commonly used for this application. Since a dc motor's speed is directly related to the voltage applied to the motor, it is critical to obtain very accurate feedback from the dc motor.

The 65C02 microprocessor uses the tachometer output to determine the thermal paper drive motor position and adjust the control voltage accordingly.

Thermal paper drive motor position information is supplied by a slotted wheel on the thermal paper drive motor through the TACH-OUT (tachometer out) signal. TACH-OUT is pulsed 6400 times for every revolution of the thermal paper drive motor. TACH-OUT passes through the I/O circuit to the 65C02 microcomputer circuit without changing.

One of the timers in the VIAs used in the 65C02 microcomputer circuit can be programmed to count negative pulses on one of the VIA input port pins. The timer is programmed with a number. As negative TACH-OUT pulses are detected on the input port pin, the counter is decremented. When a count of 0 is reached, an interrupt is generated to the 65C02 microprocessor. The 65C02 microcomputer circuit uses the position information to determine whether or not to change the voltage applied to the dc thermal paper drive motor.

Other Signals

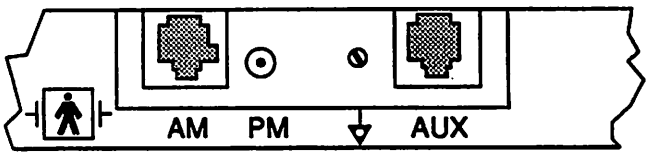
TACH-VCC supplies power to the LED (light-emitting diode) in the optical tachometer, and TACH-LED is the grounding return path from the LED. TACH-GND is the ground path from the transistor in the optically-coupled tachometer.

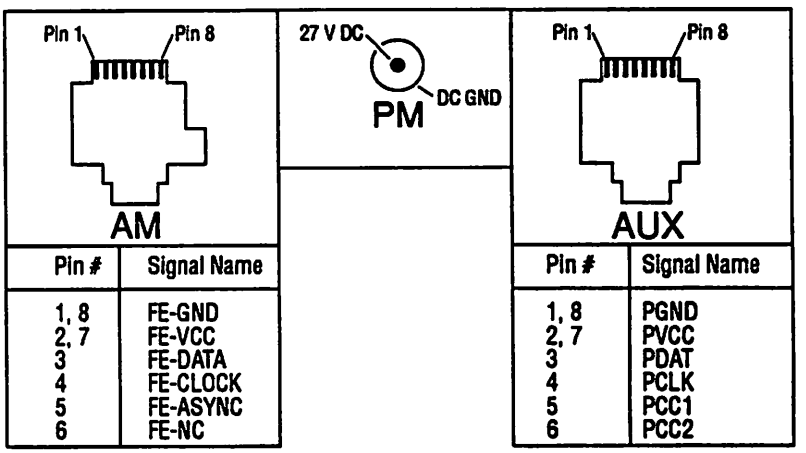
Input and Output Connectors

Information on the various input and output connectors on the MAC PC electrocardiograph begins below.

NOTE

Do not connect mains ac line voltage to any of the pins of these connectors.

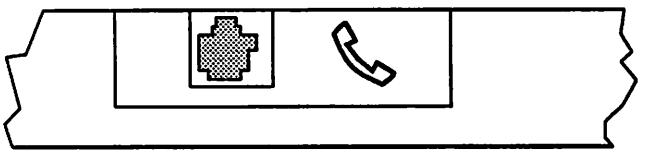


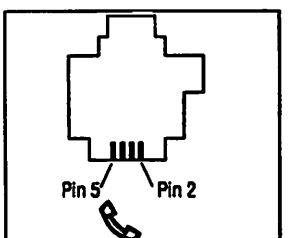


Pin #	Signal Name
1, 8	FE-GND
2, 7	FE-VCC
3	FE-DATA
4	FE-CLOCK
5	FE-ASYNC
6	FE-NC

Pin #	Signal Name
1, 8	PGND
2, 7	PVCC
3	PDAT
4	PCLK
5	PCC1
6	PCC2

Side Panel Connectors





Pin #	Signal Name
1, 2, 5, 6	Not Used
3	Tip
4	Ring

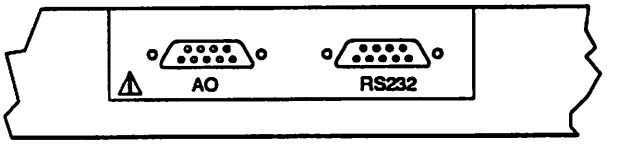
Modem Connector (Back Panel)

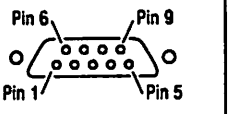
Input and Output Connectors (Cont)

The input and output connectors for the analog and RS232 output configurations are shown below.

NOTE

Do not connect mains ac line voltage to any of the pins of these connectors.

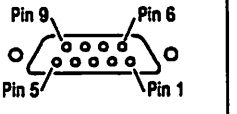




AO

Pin #	Signal Name
1	Channel 1
2	Channel 2
3	Analog Ground
4	Not Used
5	Not Used
6	Channel 3
7	Channel 4 *
8	RS232 Ground
9	TTL *

* Intended for future use. Currently not supported in software.



RS232

Pin #	Signal Name
1	NC
2	RXD
3	TXD
4	Not Used
5	RS232 Ground
6	Not Used
7	Not Used
8	Not Used
9	Not Used

Analog/RS232 Connectors (Back Panel)

Power Source Verification

Introduction

Is the MAC PC electrocardiograph's power module plugged into a power outlet that is properly wired?

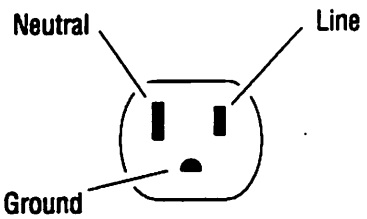
Is the power source for the power module dedicated strictly to the power module?

If many problems are experienced with the MAC PC electrocardiograph and the power source is suspected, one of the first things that should be checked is whether or not the power source is dedicated strictly to the unit's power module. If the circuit supplying power to the power module is shared with other equipment, then the other equipment using the circuit could cause noise, voltage drops, etc. A dedicated circuit is absolutely essential for the power module!

Checking the outlet for proper wiring

Often, bad wiring is overlooked as a possible source of problems. Faulty wiring in the ac outlet supplying power to the power module can cause many problems with the system. Static discharge damage, resetting problems, even noise can be a result of faulty power outlet wiring.

Using a digital multimeter, confirm that the ac source is properly wired. To do this, first measure the voltage between the 3 connection points in the power outlet. Then measure the resistance between the ground and neutral connections.



Standard 120 V ac Outlet

- A standard 120 V ac power outlet consists of 3 connections: line, neutral, and ground. See the figure at left.
- The line connection is the smaller of the 2 rectangular openings (or prongs, on a plug).
- The neutral connection is the larger of the 2 rectangular openings (or prongs).
- The ground connection is the third opening (or prong) and is usually either round or horseshoe-shaped.

Power Source Verification (Cont)

Measuring the Source Voltages

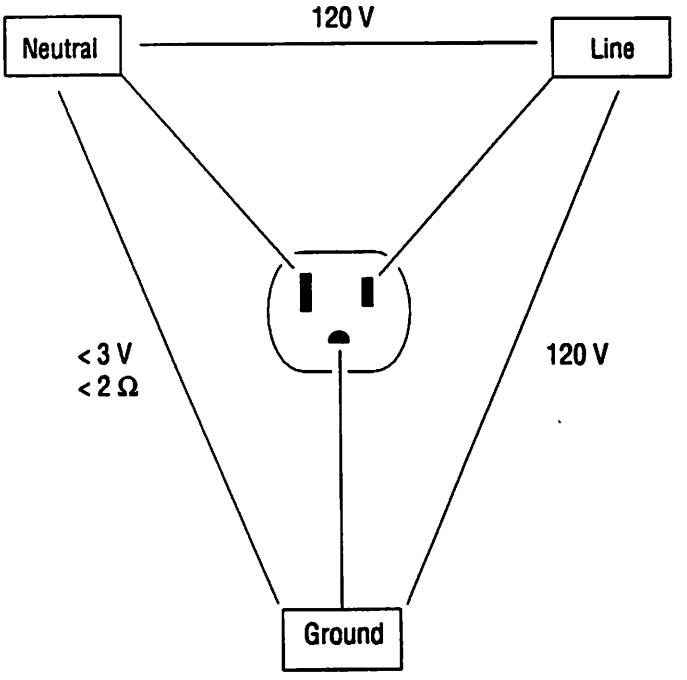
To measure the voltages present in the power outlet use the following.

- Select ac voltage on the digital multimeter.
- Measure the voltage from line to neutral, line to ground, and neutral to ground.
- If the outlet is wired properly, the following voltages should be obtained.

Line to Neutral	120 V ac
Line to Ground	120 V ac
Neutral to Ground	<3 V ac

The voltages shown to the right must be obtained! If these voltages are not obtained, then the power outlet is not wired properly. The power outlet should be checked by a qualified electrician.

Remember that these readings are nominal. Actual voltages can vary about the 120 V ac level. However, it is important that the line to neutral and line to ground voltages be essentially equal and the neutral to ground voltage should be small (<3 V).



Summary of Measurements for a Properly Wired Outlet

Power Source Verification (Cont)

Measuring the Ground-Neutral Loop Resistance

After you have confirmed that the voltages previously measured were within the acceptable range given, measure the ground-neutral loop resistance.

⚠CAUTION

Shock or burn hazard. Measure the ground-to-neutral loop resistance in a power outlet only if the voltages between the three connections in the power outlet are accurate. Otherwise, personal injury could result.

M15287-21A

If the ground-neutral loop resistance is greater than 2 ohms, have the power outlet checked by a qualified electrician.

Select the ohms scale on the digital multimeter. Measure the resistance between the ground and neutral connections on the power outlet. The resistance should be less than 2 ohms. If the resistance is greater than 2 ohms, have the power outlet checked by a qualified electrician.

Checking for Continuity Between the Wall Outlet and Plug, and in the Power Cord

Sometimes the wall outlet gets worn, and even though the outlet checks out, the power cord is not making contact. Try removing the power cord from the MAC PC electrocardiograph's power module, plugging it into the wall outlet, and rechecking the cord receptacle as you did the wall outlet. If a continuity check on the power cord is good, then the outlet may need replacement by a qualified electrician.

Powerup Selftest Troubleshooting

Introduction

If the powerup selftest finishes with the Main Menu displayed on the lcd, much of the MAC PC electrocardiograph is working acceptably.

The MAC PC electrocardiograph "sleeps" most of the time. When it is needed for use, first the 65C02 microprocessor is started up. The 65C02 then starts the 68000 microprocessor as it is required for special tasks.

As the microprocessors are powered up, they perform selftest programs on their memory and interface circuits. Once these tests are completed, the Main Menu is displayed on the lcd. What occurs as these selftests are running can identify problems in the MAC PC electrocardiograph.

As the selftests are performed, a message is shown on the lcd. Just having this message displayed indicates that the 65C02, lcd, and most of the 68000 circuits are operating. Getting to the Main Menu display indicates that 68000 memory has been tested and seems to be working.

Just having the Main Menu displayed on the lcd, and being able to press the keys and get responses, indicates that most of the MAC PC electrocardiograph is operating. This could be considered a type of a very simple minimum performance test of the MAC PC electrocardiograph. To check other circuits, an ECG must be acquired, analyzed, and printed by the writer.

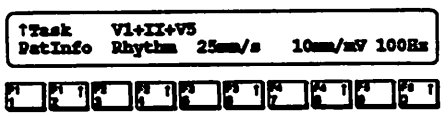
If the Main Menu is not displayed, then a problem exists.

The majority of this chapter concerns problems that occur while the powerup selftest is running or when it finishes with an error message. Various topics describe troubleshooting assemblies that can be replaced or repaired in the field, if the technician is qualified. Note, that this chapter deals with testing the MAC PC electrocardiograph electronics. Board replacement is often the recommended repair.

Powerup Selftest Troubleshooting (Cont)

No Characters on the LCD

When the MAC PC electrocardiograph is powered up, characters should appear on the lcd.



When the MAC PC electrocardiograph is turned on (powered up), the 65C02 microprocessor on the processor pcb assembly sends data to the lcd for display. As the selftests are run, more data is sent to the lcd.

Part of the display during the selftests shows the version number of the operating software program installed in the MAC PC electrocardiograph. As tests are completed, the display shows what has been done (by showing *Self Test 1*, *Self Test 12*). After the tests are complete and if no faults are detected, the Main Menu is displayed.

If the lcd remains blank after powerup or if there are only dark lines across it, the powerup selftests are not running or the lcd could have failed.

To check the lcd, listen for small key clicks while pressing the switch. If you can hear the small clicks, try adjusting the lcd contrast. Hold down and either the or to increase or decrease, respectively, the lcd contrast.

If you hear no sounds while pressing the switch, suspect a discharged battery.

The next several paragraphs describe troubleshooting steps to locate the problem.

First suspect a problem with either the power module or the batteries.

Two of the most likely problems that could result in no characters on the lcd are the power module (charger) and the batteries. If the power module has failed, the batteries will eventually discharge completely. This could result in no display.

Try substituting a good power module.

To determine if the problem is the power module, try substituting a known good (able to successfully charge the batteries in another MAC PC electrocardiograph) power module. If a substitute power module is not available, return both the power module and the MAC PC electrocardiograph to the Marquette Service Division for repair.

A good power module will always cause the message *Charging* to be displayed when the battery status is shown. The *Charging* message should appear in the lower right corner of the display. To get the battery status display, hold down the power switch.

Note, the PM-2 power modules have LEDs to indicate ac or dc power. If either LED remains unlit when the power module is plugged into the MAC PC electrocardiograph, suspect a problem with the power module. The Main Menu should be displayed on the MAC PC electrocardiograph when you plug in the power module.

Powerup Selftest Troubleshooting (Cont)

No Characters on the LCD (Cont)

If the *Charging* message is shown with the substitute power module, but not with the original, the original power module should be replaced or repaired.

Generally, measuring the voltage output of a power module is a good indication that the power module is good, although not a guarantee.

Using the substitute power module, let the batteries charge for a few hours,

then try again to power it up.

If a known good power module is connected to the MAC PC electrocardiograph and the lcd remains blank at powerup, the batteries could be completely discharged. While in this state, the batteries will draw all available power from the module and the MAC PC electrocardiograph will not power up in the normal manner. The lcd may be faint and the normal connection sound ("beep") may not be present or be very weak. Try letting the batteries charge for 2 hours, then attempt to power up the MAC PC electrocardiograph.

If there is still no display, check fuse F1 on the processor pcb assembly.

If after charging for 2 hours there is still no activity on the lcd when you attempt to power up the MAC PC electrocardiograph, there could be a blown fuse. Look inside the unit. (See "Opening the Unit for Service" in chapter 3, Maintenance, for instructions.)

NOTE

Since the battery is disconnected during this procedure, all stored ECG data and setup information is lost.

Check fuse F1 on the processor pcb assembly. This picofuse is located at the lower left corner of the processor pcb assembly and often looks just like a resistor. Note, the red band on one end of the fuse, this means it is a 1 A fuse, pn 1909-008.

You do not have to remove the processor pcb assembly to replace fuse F1.

When replacing fuse F1, you can clip out the old fuse then solder the new one directly to the oversize solder pads. Be careful to trim the leads of the new fuse so they do not touch other components or traces. Note, this procedure eliminates removing the processor pcb assembly from the MAC PC electrocardiograph.

If there is still no display, check socketed components and cables.

If there is still no display on the lcd, check all socketed components (particularly U8 on the processor pcb assembly) for bent pins. Verify that all cables are connected properly.

Powerup Selftest Troubleshooting (Cont)

No Characters on the LCD (Cont)

To continue troubleshooting, another known good MAC PC electrocardiograph is required.

If all of the preceding troubleshooting steps have been tried, but still there is no display on the lcd, consider returning the MAC PC electrocardiograph to the Marquette Service Division. Further troubleshooting requires access to another working MAC PC electrocardiograph.

If you have access to another MAC PC electrocardiograph that is known to be operating satisfactorily, make sure it can be disassembled before continuing.

Swap the cover from the good MAC PC electrocardiograph with the cover on the problem MAC PC electrocardiograph.

Remove the cover from the good unit and install it on the problem unit. (See "Opening the Unit for Service" in chapter 3, Maintenance, for instructions.)

Connect the keyboard/lcd cables to the processor pcb assembly and then connect the battery cable to the processor pcb assembly.

Attempt to power up the problem unit. If the powerup selftest and then the Main Menu are displayed, the problem lies in the removed cover. Replace the keyboard assembly (since it includes the lcd), pn 88694-001.

If there is still no activity on the lcd, then either replace the processor pcb assembly, pn 85599-00X and its software, or return the MAC PC electrocardiograph to the Service Division for repair.

If only a black line is displayed on the lcd...

If the lcd shows only a black line across the top row, replace the processor pcb assembly, pn 85599-00X, or return the MAC PC electrocardiograph to the Service Division for repair.

Incomplete Selftest

If the powerup selftest ends with one of the following messages on the lcd:

MAC-PC Pgm 005X Self Test, or
MAC-PC Pgm 005X Self Test 1, or
MAC-PC Pgm 005X Self Test 12,

this indicates that a failure was detected on the processor pcb assembly.

If the unit powers up and gets to the selftest displays, you know that at least some of its circuits are working. If the powerup sequence stops on one of the selftest displays, as shown to the left, then a problem has been detected by the 68000. Either replace the processor pcb assembly or return the MAC PC electrocardiograph to the Service Division for repair.

Powerup Selftest Troubleshooting (Cont)

Bad RAM or *Check Sum* Error Messages

Bad RAM

This error message indicates that a problem was detected during testing of the processor pcb assembly RAM. The recommended repair is to replace the processor pcb assembly, pn 85599-00X, or return the MAC PC electrocardiograph to the Service Division for repair.

Check Sum U4 XXXX Should Be XXXX

This error message indicates that a problem was detected during testing of the processor pcb assembly EPROMs or EPROMs on any expansion boards. The error message indicates which EPROM has the problem. The recommended repairs are:

- make sure that jumper W1 is installed correctly for the size EPROMs being used, or
- verify that the EPROMs (software) on the expansion, modem, or analog/serial output pcb assembly are compatible with the processor pcb assembly software, or
- replace the problem EPROM, or
- replace all of the software (all EPROMs), or
- replace the processor pcb assembly or the expansion, modem, or analog/serial output pcb assembly (depending upon what you have) and the software (EPROMs), or
- return the MAC PC electrocardiograph to the Service Division for repair.

If this error message is intermittent, resolder connector J1 on the expansion, modem, or analog/serial output pcb assembly.

Powerup Selftest Troubleshooting (Cont)

Entry Error Error Message

Entry Error #1 Retry XXX

This error message is displayed, then the display starts showing a number count going from 001 to 256, and finally the display goes blank. You have 2 options: return the MAC PC electrocardiograph to the Service Division for repair or try to determine which printed circuit board is bad.

To determine which printed circuit board is bad, perform the following procedure.

NOTE

Since the battery is disconnected during this procedure, all stored ECG data and setup information is lost.

- Remove the cover. (See "Opening the Unit for Service" in chapter 3, Maintenance, for information.)
- Remove the expansion, modem, or analog/serial output pcb assembly from the processor pcb assembly.
- Connect the battery cable to J9 on the processor pcb assembly.
- Powerup the MAC PC electrocardiograph and observe the selftest messages.

Check Sum U4 XXXX Should Be XXXX

- If the display shows a checksum error message, replace the expansion, modem, or analog/serial output pcb assembly (whichever is present).
- Reassemble the unit. (See "Basic Reassembly" in chapter 3, Maintenance, for details.)

Entry Error #1 Retry XXX

- If the display shows the entry error message again, replace the processor pcb assembly and the software.
- Reassemble the unit.

Powerup Selftest Troubleshooting (Cont)

Displays Resulting from a Completely Discharged Battery

All Stored ECGs Have Been Lost

Bad Setup Values-Setting to Defaults

Setup Data Lost, Restoring to Defaults

These messages indicate that the battery has discharged completely and the MAC PC electrocardiograph has aborted all setup and stored ECG data. All of the setup data will have to be reentered once the MAC PC electrocardiograph is fully charged. The operator's manual has information on the setup options. (See "Related Manuals" in chapter 1, Introduction.)

To completely recharge the battery, the unit must be connected to the power module and left to charge for 12 to 14 hours.

For limited use, although the battery gauge may show a charge of 0/50, 3 to 4 hours of charging time is required.

4 tones are generated every 4 minutes

If the MAC PC electrocardiograph emits 4 brief tones when it is powered up and again approximately every 4 minutes thereafter, this indicates that the charge in the battery is very low. Recharge the battery for 12 to 14 hours.

8 to 10 beeps are generated

If the MAC PC electrocardiograph emits a series of 8 to 10 beeping tones, the battery charge level has dropped to a point where the unit may abort. All stored ECG data and the setup data may be lost if the unit aborts.

Recharge the battery for 12 to 14 hours. If the MAC PC electrocardiograph did abort, you may have to reprogram the setup data. The operator's manual contains more information on programming the setup data. (See "Related Manuals" in chapter 1, Introduction.)

Powerup Selftest Troubleshooting (Cont)

Battery Charger Problems

The *Not Charging* message indicates a problem with...

If the *Not Charging* message is shown in the battery status display during powerup, there could be a problem with the battery, battery charging circuit, or power module.

Connect a known good power module to the MAC PC electrocardiograph. (If 1 is not available, return the MAC PC electrocardiograph and the power module to the Marquette Service Division for repair.)

the power module or

If the *Not Charging* message no longer appears after connecting a known good power module, the original power module should be tested. See chapter 5, Power Modules, for this testing procedure.

the battery charging circuit.

If the *Not Charging* message still is displayed after connecting a known good power module, then the problem may be with the battery charging circuit. Perform the following procedure.

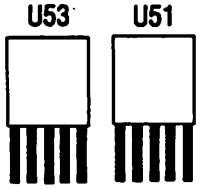
NOTE

Since the battery is disconnected during this procedure, all stored ECG data and setup information is lost.

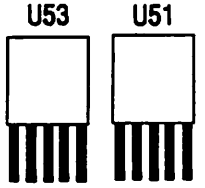
- Remove the cover. (See "Opening the Unit for Service" in chapter 3, Maintenance, for instructions.)

Powerup Selftest Troubleshooting (Cont)

Battery Charger Problems (Cont)



Writer 1
(Located on Front Side of Writer)



Writer 2
(Located on Front Side of Writer Assembly)

- Replace regulator U53 (located on the writer assembly). This regulator controls the battery charging power. It might be necessary to remove the writer assembly from the MAC PC electrocardiograph to do this replacement. See chapter 7, Writer 1, and chapter 8, Writer 2, for suggestions on removing the writer assembly. Note, that the writer assembly will have to be realigned if it is removed.
- Close the unit. (See "Basic Reassembly" in chapter 3, Maintenance, for instructions.)
- Power up the unit.

If the message still is displayed after replacing U53, return the MAC PC electrocardiograph and power module to the Marquette Service Division for repair.

Charging message is shown, but the power module is not connected.

If the power module is not connected but the *Charging* message is shown, either:

- replace CR14, pn 2050-821, on the processor pcb assembly, or
- replace the processor pcb assembly, or
- return the MAC PC electrocardiograph to the Marquette Service Division for repair.

The *Sho* and *Chg* calibration utilities can be used to troubleshoot the battery charger circuit.

The *Sho* and *Chg* calibration utilities can be used to troubleshoot the battery charger circuit. See the paragraphs titled "Manufacturing Menu" in chapter 2, General Information.

Powerup Selftest Troubleshooting (Cont)

Additional Troubleshooting Tips

The unit will not power up.

If the MAC PC electrocardiograph will not power up, measure the battery charger output voltage.

Is the battery charger output voltage 27-28 V?

If yes

- Check fuse F1 (pn 1909-008) on the processor pcb assembly, pn 85579-00X.
- If fuse is open, check VR8 (pn 2002-305) for a short before replacing F1 fuse. If VR8 is shorted, replace it.
- Check the battery output for the following:

— Red to Black	20 volts
— White to Black	15 volts
— Green to Black	10 volts
— Blue to Black	5 volts

The battery can die even if it is not used. We recommend that your spare batteries be deep-discharged/charged 1 to 2 times a year.

- If after charging the battery or exchanging the processor pcb assembly the lcd does not come on and the speaker is activated, darken the lcd by pressing and holding the "SHIFT" key and pressing the "UP ARROW" key.

If no

- Check the internal fuse in the transformer by checking for continuity between pins 7 and 9 (MAC PC electrocardiograph with PM-2 power module only). If it is open, replace the transformer [pn 1401-210 (120/240) or pn 1401-211 (100/200)].
- Check the dc power cord (pn 80630-001).
- On PM-2 power module, check the LED's (pn 2493-101). If they are opened, cracked, or broken off, the charger will not charge.

Software/Hardware Configurations

Introduction

The operating characteristics of the MAC PC electrocardiograph vary slightly according to the version of software that is installed. Also, the MAC PC electrocardiograph may be configured with an EPROM expansion pcb assembly, a modem pcb assembly, or an analog/serial output pcb assembly. The functions of the unit depend upon which printed circuit boards are installed.

First, some information for installing new software is provided. With new software, the unit will power up in a mode requiring a password and initialization before the Main Menu appears. This information outlines the recommended method for getting through the initialization.

Software Versions

The various versions of operating software are then listed in chronological order. The EPROM part numbers are listed for each version for reference. Be sure you install the correct part numbers!

The operating characteristics of the MAC PC electrocardiograph vary according to the software installed.

For each software version, there is information on options or operating characteristics worth noting. This should help explain why the MAC PC electrocardiograph operates just a little bit differently with the new software.

Software/Hardware Configurations (Cont)

Installing New Software

This procedure describes installing new software in units with processor pcb assemblies, pn 85599-002 or newer. Standard hand tools are the only tools required. Discard all replaced parts.

As a quick overview, these are the steps to follow to install new software.

- Write down or print out setup information that will have to be reentered after new software is installed. Transmit all stored ECGs.
- Turn off power. Unplug power module, if connected. Unplug any other external connectors, as well.
- Open the unit.
- Disconnect the battery cable from J9 on the processor pcb assembly.
- Remove and set aside any optional pcb assemblies.
- Remove 3 ICs from the processor pcb assembly.
- Install 3 new ICs.
- Replace optional pcb assemblies.
- Reconnect the battery cable to J9 on the processor pcb assembly.
- Close the unit.
- Perform checkout procedure.

Be careful of static!

Be sure to discharge any static charge you may have built up before beginning this procedure. Wear a grounded, anti-static strap. Work on a static-free work surface.

Software/Hardware Configurations (Cont)

Installing New Software (Cont)

```
MAC PC Setup Settings    08-NOV-91 12:58

Phone Numbers
  Number1
    Phone Number 1 Description.....
    Phone Number 1.....
  Number2
    Phone Number 2 Description.....
    Phone Number 2.....
  Number3
    Phone Number 3 Description.....
    Phone Number 3.....
  Number4
    Phone Number 4 Description.....
    Phone Number 4.....

Lead Groups
  Rhythm
    AutoRhythm.....V1, II, V5
    Group1.....I, II, III
    Group2.....aVR, aVL, aVF
    Group3.....V1, V2, V3
    Group4.....V4, V5, V6
```

NOTE

Whenever the battery cable is disconnected from J9 on the processor pcb assembly, all stored ECG data and setup information is lost.

Since the battery cable must be disconnected during this procedure, all stored ECGs should be transmitted (if that is what is normally done with the ECG data) and all setup information written down. With 006/106 and later software, the setup information can be printed out. Select *"Print"* under Cart Setup. You will have to reenter this information after the software is installed.

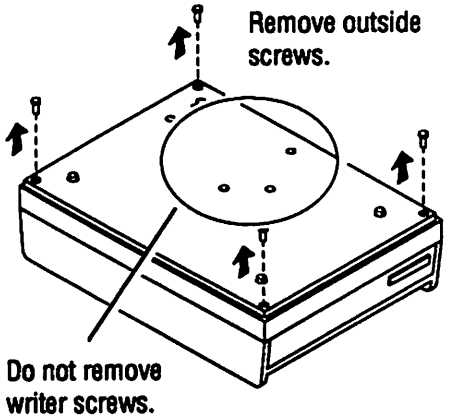
- Write down the battery gauge value.

  To display this value, press and hold down the power switch. (When the battery cable is disconnected, the gauge is set to 0.)

- Write down the thermal print head value.

  This number is written on a label placed on the front of thermal writer casting. (See illustration below.)

Use the  switch to remove power. Turn off and unplug power module, if connected. Unplug any other external connectors, as well.

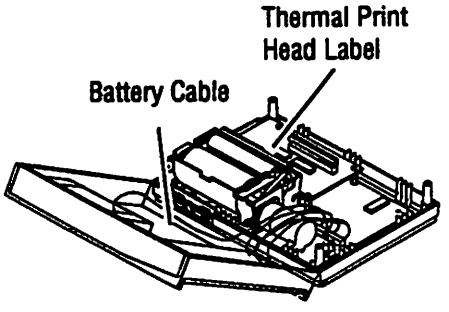


NOTE

In order to prevent damage to the pcb assemblies, be sure that you are connected to an anti-static strap. Be careful not to bend the pcb assemblies.

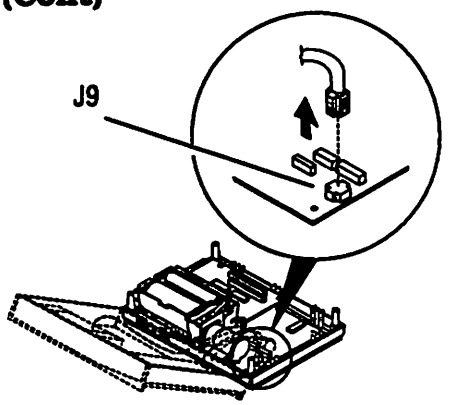
Remove the outer screws which hold the 2 halves of the unit together. Do not remove the writer screws.

Lift top half and turn over carefully. The 2 halves of the unit are connected by cabling.



Software/Hardware Configurations (Cont)

Installing New Software (Cont)



NOTE

You MUST disconnect the battery cable from J9 on the processor pcb assembly first. Failure to do so could cause severe damage to the processor pcb assembly.

Disconnect the battery cable from J9. Remember the battery cable is disconnected first and reconnected last.

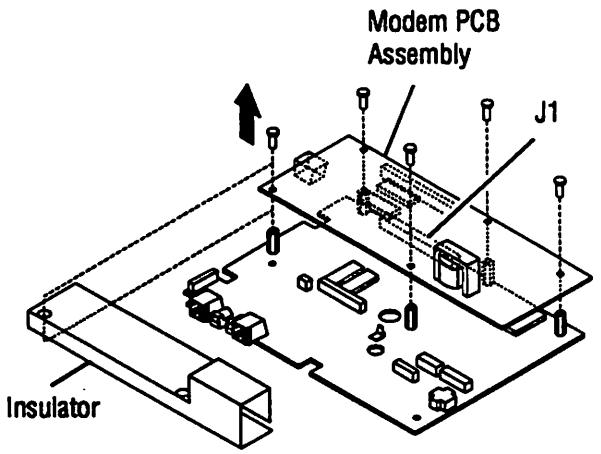
NOTE

In order to prevent damage to the pcb assemblies, be sure that you are connected to an anti-static strap. Be careful not to bend the pcb assemblies.

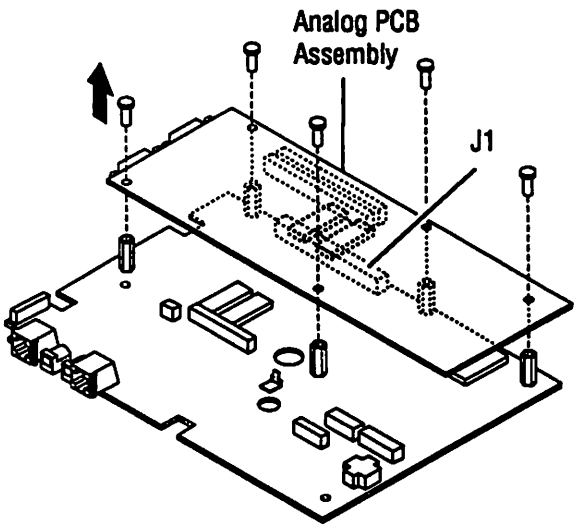
Remember to save and set aside all removed hardware.

Carefully remove any optional pcb assembly (modem, analog) that is connected to the processor pcb assembly. Set aside all removed hardware.

DO NOT bend pins on J1 connector on processor pcb assembly while removing pcb assembly. This could cause a malfunction after installation has been completed.

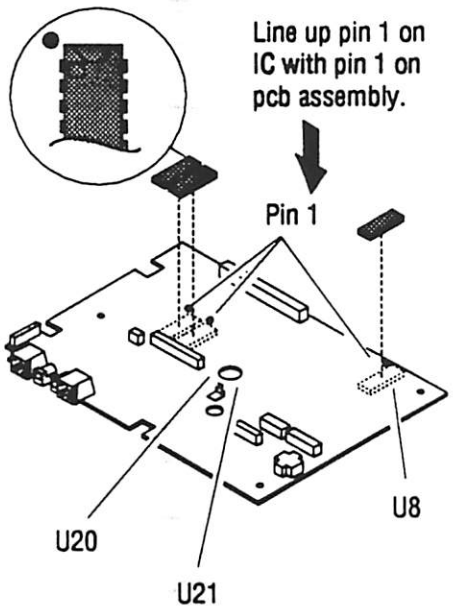


OR



Software/Hardware Configurations (Cont)

Installing New Software (Cont)



NOTE

When removing ICs from pcb assembly, DO NOT apply downward pressure on the pcb assembly with removal tool. Otherwise damage to the pcb assembly could result.

Carefully remove and discard firmware ICs U8, U20, and U21 from the processor pcb assembly.

NOTE

When inserting ICs into pcb assemblies, check to make sure that all pins are aligned with the sockets before you apply pressure to snap ICs into place.

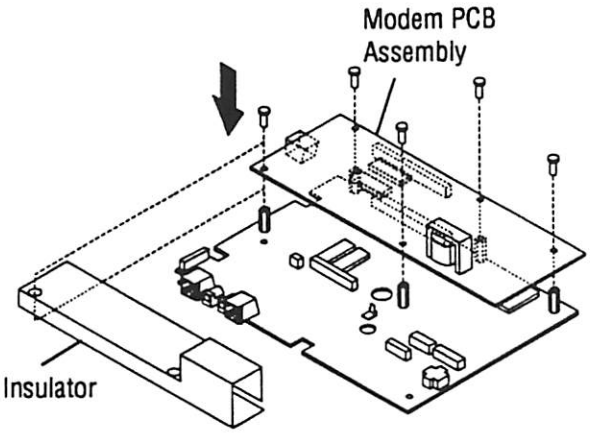
Insert new firmware ICs, in positions U8, U20, and U21, on the processor pcb assembly.

After insertion, double check for bent pins.

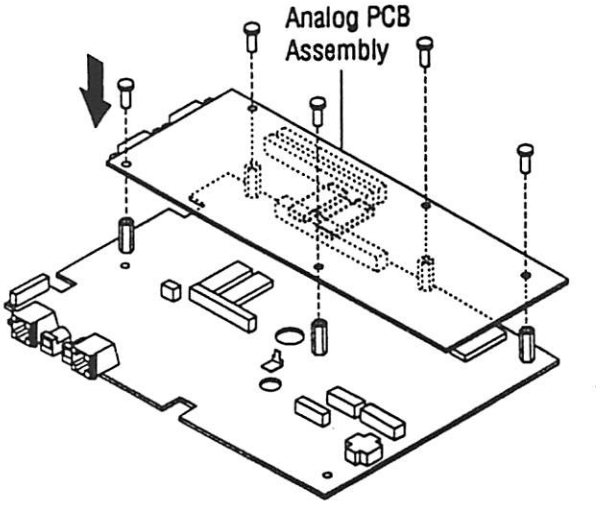
Be sure to line up pin 1 on IC with pin 1 designation on processor pcb assembly.

Replace the optional pcb assembly, previously removed.

Be sure the modem insulator is installed with the modem pcb assembly.

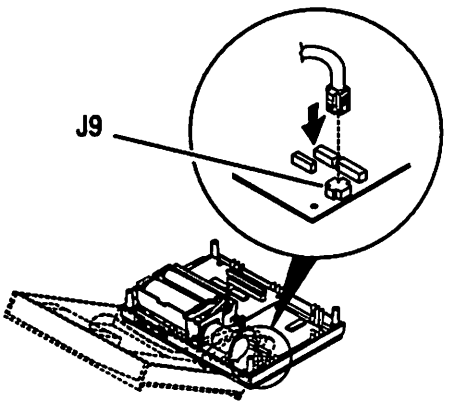


OR



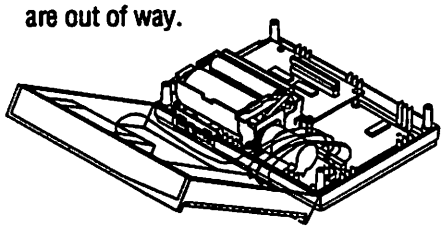
Software/Hardware Configurations (Cont)

Installing New Software (Cont)

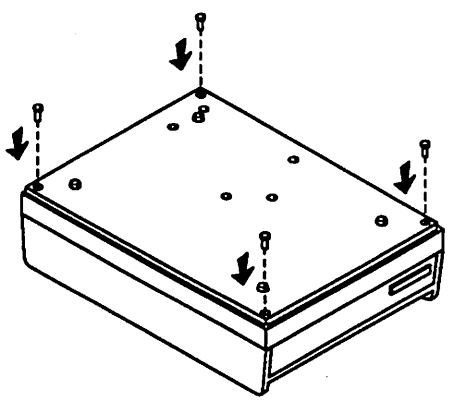


Reconnect the battery cable to J9 on the processor pcb assembly last.

Check that cables are out of way.



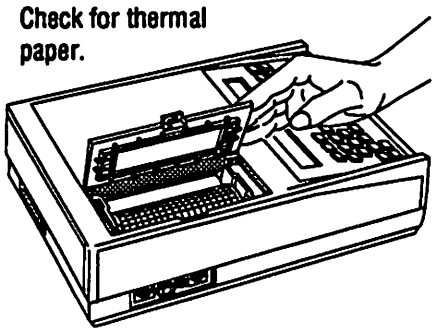
Before closing the unit, check to make sure that all cables/ harnesses are tucked out-of-the-way and will not be crimped or pinched when unit is closed.



Replace screws in base.

Software/Hardware Configurations (Cont)

Installing New Software (Cont)



Next you will need to reprogram the MAC PC electrocardiograph with the information you wrote down before beginning the procedure. Before beginning make sure there is thermal paper in the thermal writer.

Use the [ON/OFF] key to apply power.

```
ENTER PASSWORD
PGM 83350-006A
```

When the lcd message asks for a password, type "MACPC". Press [↵]. This is indicated on the lcd by "<CR>".

```
MfgHedAdjEngSavLodBrnResHotShoBatChgEnd
```

Type "Mfg". Answer "Yes" to *Set Defaults*. Press [↵].

```
SET DEFAULTS ?    YES
 YES      NO
```

```
HEAD VOLTAGE 15.0
PRESS <CR> TO ACCEPT. STOPKEY TO QUIT
```

Next *HEAD VOLTAGE 1X.X* appears. Confirm that the thermal print head voltage shown on the lcd matches the value that was on the label. If it is correct, press the stop key.

If it is not, enter the correct value. The tens column cannot be changed. Press [↵].

```
Writer Calibration
PRESS <CR> TO CONTINUE
```

The *Writer Calibration* prompt follows next. Press [↵]. The writer starts its internal calibration with a thermal paper speed of 25 mm/s, then 10 mm/s, and finally at 5 mm/s.

```
Configuration complete
Press any key to continue
```

```
MfgHedAdjEngSavLodBrnResHotShoBatChgEnd
```

When the calibration is complete, the message shown to the left is displayed.

```
ENTER VALUE FOR BATTERY GAUGE
          [ 32 ]
```

Return to the Manufacturing Menu. Type "Bat". Enter the battery gauge value. Press [↵].

Software/Hardware Configurations (Cont)

Installing New Software (Cont)

```
MAC-PC Pgm 108A Selftest 1
```

Return to the Manufacturing Menu. Type "END". Press [⏎].

Next, the status of the battery is displayed very briefly. This is followed by a selftest. The software version installed in the unit is displayed as part of this test.

If the new software version number appears, this verifies that the installation was successful. If a problem occurs during any of the above programming steps, verify that the ICs are inserted completely and all cabling is connected.

```
MAC PC Setup Settings    08-NOV-91 12:58

Phone Numbers
  Number1
    Phone Number 1 Description.....
    Phone Number 1.....
  Number2
    Phone Number 2 Description.....
    Phone Number 2.....
  Number3
    Phone Number 3 Description.....
    Phone Number 3.....
  Number4
    Phone Number 4 Description.....
    Phone Number 4.....

Lead Groups
  Rhythm
    AutoRhythm.....V1, II, V5
    Group1.....I, II, III
    Group2.....aVR, aVL, aVF
    Group3.....V1, V2, V3
    Group4.....V4, V5, V6
```

The final step is to reenter all of the setup values that you wrote down or printed out. You can do this as part of the Cart Setup Menu. For details, see operator's manual. (See "Related Manuals" in chapter 1, Introduction.)

Software/Hardware Configurations (Cont)

Software Version 104

EPROM Part Numbers

On the processor pcb assembly:

U8 83350-003E
U20 83351-003A
U21 83352-003A

On the EPROM expansion or modem pcb assemblies:

U4 83464-001A
U16 83465-001A

Options and operating characteristic changes worth noting...

In the writer diagnostics, the speed and roller tests are combined.

Setup is reached through the shifted F1 key (also known as F1-2 or 2 key).

PatInfo is reached through the F1 key (also known as F1-1 or 1 key).

Thermal paper speeds are only 25 and 5 mm/s. There is no simulated 50 mm/s.

The auto timeout function can be reached in the Manufacturing Menu under *Aut* or *Mfg*.

Local and reverse transmission are supported.

Defaults to RMR report format.

No editing is allowed.

No password protection is offered.

No pediatric analysis is offered.

No control of the battery gauge is provided (part of the Manufacturing Menu).

Software/Hardware Configurations (Cont)

Software Versions 004A and 004B

EPROM Part Numbers

On the processor pcb assembly:

U8 83350-004A
U20 83351-004B
U21 83352-004B

Options and operating characteristic changes worth noting...

On the EPROM expansion or modem pcb assemblies:

U4 83464-002B
U16 83465-002B

Editing is supported.

Local and reverse transmission are supported.

Password protection of data is offered.

Pediatric analysis is available.

Defaults to the 4 x 2.5 (1 page) report format.

The left facing arrow is used for thermal paper advance.

The auto timeout function can be reached in the Setup Menu.

Thermal paper speeds are 5, 10, and 25 mm/s with a simulated 50 mm/s speed while in the record ECG mode.

The *Bat* function is included in the Manufacturing Menu.

The *Mot* writer calibration test in the Manufacturing Menu has 3 speeds.

The auto timeout function was deleted from the Manufacturing Menu and moved to the Setup Menu.

Known problems with this software...

Editing. When selecting all ECGs for editing, under the full editing mode, occasionally the MAC PC electrocardiograph would print an incorrect report after finishing the edit mode. The edited ECG is correct when plotted through the Storage Functions Menu. Only the first plot to be run, after editing any report, was found to be incorrect.

Baseline. The baseline is slow to stabilize while in the rhythm mode.

were all corrected by 005C software.

Patient Info. When the D selection is made for the medication prompt under Patient Information, the MAC PC electrocardiograph always picked Digoxin.

Software/Hardware Configurations (Cont)

Software Version 005C

EPROM Part Numbers

On the processor pcb assembly:

U8 83350-006B
U20 83351-005C
U21 83352-005C

On the EPROM expansion, modem pcb, or analog/serial output pcb assemblies:

U4 83464-003B
U16 83465-003B

Options and operating characteristic changes worth noting...

If the D and B keys are held down and the power switch is pressed momentarily, a battery program starts. The power module and acquisition module should be connected. The program automatically deep discharges the batteries and then recharges them. The entire process requires 14 to 16 hours.

The analog output function is now supported, if an analog/serial output pcb assembly is installed.

RS232 output is supported.

The user can suppress abnormal and borderline statements in the report through a selection in *Misc* under Setup Menu.

In the Manufacturing Menu, the default value for the out of paper (*PO-LIM*) parameter (part of *Mot* utility) is changed to 98 to accommodate the new thermal print head, pn 1479-003.

The auto timeout function, in the Setup Menu, was changed so that if the unit times out it will return to the previous menu when the power switch is pressed. There is no prompt for auto timeout any longer.

Software/Hardware Configurations (Cont)

Software Version 105A

The operating characteristics are the same as 005C software.

Software version 105A operates the same as software version 005C. The 105 indicates that 1 megabyte EPROMs are used on the processor pcb assembly.

EPROM Part Numbers

On the processor pcb assembly:

U8 83350-006B
U20 83351-105C
U21 83352-105C

Note, U20 and U21 are 32-pin ICs. U4 and U16 are not used on the modem and analog/serial output pcb assemblies.

An EPROM expansion pcb assembly is unnecessary since all system software is located on the processor pcb assembly. (On the pn 85599-002 version of the processor pcb assembly, the components of the EPROM expansion pcb assembly are incorporated in the processor pcb assembly, and therefore, the EPROM expansion pcb assembly is not required.)

The processor pcb assembly, pn 85599-002 and later revisions, can accommodate the 32-pin EPROMs. The processor pcb assembly, pn 85599-001, has 28-pin sockets only.

Software Version 006A/ 106A

Both software versions operate in the same manner.

Software version 006A operates the same as software version 106A. The difference relates to the size of the EPROMs in which the information is stored.

For 006A, the following EPROMs are used.

EPROM Part Numbers

On the processor pcb assembly, pn 85599-001:

U8 83350-006B
U20 83351-006A
U21 83352-006A

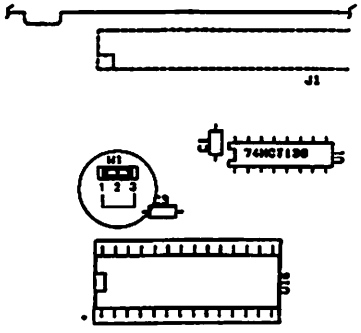
On the EPROM expansion, modem, or analog/serial output pcb assemblies:

U4 83464-004A
U16 83465-004A

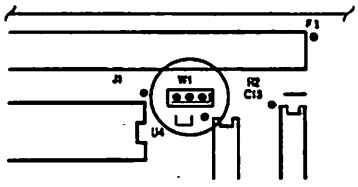
Software/Hardware Configurations (Cont)

Software Version 006A/ 106A (Cont)

More EPROM Part Numbers



EPROM Expansion PCB Assembly



Modem PCB Assembly

There is a jumper change required on the EPROM expansion and modem pcb assembly. On the EPROM expansion pcb assembly, the 2 outside pins on W1 should be shorted together. On the modem pcb assembly, the center pin and the pin nearest to U4 should be shorted together. (For details, see circled areas on illustrations shown to the left.)

For 106A, the following EPROMs are used.

On the processor pcb assembly, pn 85599-002 and later versions:

U8 83350-006B
U20 83351-106A
U21 83352-106A

Options and operating characteristic changes worth noting...

Transmission

- The MAC PC electrocardiograph can now store 4 telephone numbers in Setup. Each number has a 7 character field that can be used to describe the number (eg hospital name). These numbers can be used during direct transmission from a patient and memory.

Direct Transmit

- The MAC PC electrocardiograph will always use telephone number 1 when transmitting directly from a patient. If telephone number 1 is empty, the unit will prompt the operator to enter a telephone number.

  If more than 1 telephone number has been entered in Setup, the MAC PC electrocardiograph will prompt the operator to select another telephone number after the ECG has been sent to telephone number 1. This allows the operator to transmit the same ECG to more than 1 telephone number.

  Note, unlike Batch Transmission, this "retransmission" feature will work even if the unit has been programmed to delete ECGs after transmission.

Software/Hardware Configurations (Cont)

Software Version 006A/ 106A (Cont)

Batch Transmission

- Batch transmission will function the same as previous versions of software if only 1 telephone number is programmed in Setup. If more than 1 telephone number is defined, a new menu will appear that prompts the operator to select a telephone number. The telephone number descriptions that were programmed in Setup are used as softkey labels.

  The actual telephone number will appear on the top line of the display after the softkey is pressed. After the selected ECGs have been transmitted, the MAC PC electrocardiograph will prompt the operator to select another telephone number. This allows the operator to transmit the same ECG(s) to more than 1 number.

  Note, this "retransmission" feature will not work if the unit has been programmed to delete ECGs after transmission. (Delete is the default.)

AM-3 Acquisition Modules

- The MAC PC electrocardiograph supports the control of lead-fail bias in AM-3 acquisition modules with the LE product code only.

  The MAC PC electrocardiograph supports the control of the pace spike enhancer in the AM-3 acquisition module.

Dynamic Sizing for ECG Storage

- This feature was added to eliminate the need for separate EPROMs for different memory configurations. The MAC PC electrocardiograph is currently available in only 1 RAM configuration (128K). If additional memory is added in the future, this software will automatically recognize the change.

"WORKING" Message Added

- Stored ECGs are verified whenever the Storage or Reverse Transmission functions are selected. If several ECGs are stored, this causes a noticeable delay. A "WORKING" message is now displayed during the memory verification process.

Software/Hardware Configurations (Cont)

Software Version 006A/ 106A (Cont)

Diagnostic Test Changes

- The "All/Ram" and "SumRam" functions have been removed from the memory diagnostic test (part of Hardware Diagnostic Menu). The "W/R" (Write/Read) function is now destructive and will destroy Setup values and stored ECGs. It is protected by the level 1 password. If "W/R" is selected, the following prompt is displayed: "Setup & ECG data will be lost: Quit/Continue."

  If the Continue softkey is pressed, the W/R test will start and all of the Setup values and stored ECGs will be lost. (Note, the user can now print a copy of all Setup values.)

  A "TESTS" counter will increment (in hexadecimal) with the completion of each pass through memory.

  The "ERR1" and "ERR2" fields should remain at zero. This test will run until halted by pressing the "STOP" key at which time the MAC PC electrocardiograph will start a powerup self test.

ECG Selection by Patient ID

- The patient ID may now be used to select ECGs for plotting, editing, deleting, or transmitting.

Order of ECG in Menus

- Previously, when selecting ECGs for plotting, editing, deleting, or transmission, the oldest ECGs were presented first. Now the most recent ECG is presented first.

Storage Menu Changed

- The "TRANSMIT" has been moved to the first menu. In earlier software versions, this function was in the "MORE" menu.

Printing of Setup Values

- The setup menu now has a "PRINT" function. This allows the operator to print a hard copy of the setup values.

New 12SL Program

- Version 6/108 of the 12SL program has been added. This adds the new statement "** ** ACUTE MI ** **."

Order of ECGs Transmitted in Batch Mode

- ECGs are sorted before batch transmission so that the oldest ECGs are transmitted first. This fixes a problem with serial comparison in MUSE system.

RS232 Transmission Added

- This feature allows the unit to receive compressed ECGs transmitted with the XMODEM protocol. The ECGs can be sent from a MUSE system, another electrocardiograph (MAC PC/6/15), or a personal computer. A baud rate of 19.2 Kbaud can be used only if 2 stop bits are used.

Software/Hardware Configurations (Cont)

Software Version 006A/ 106A (Cont)

New Questions in RS232 Setup

- "Transmit Data Format/All Data or Compressed Data" added. This question controls the format of data transmitted in the "RS232 Transmit" function. This question used to be asked whenever RS232 Transmit was selected.

  "RS232 Line Connected to MUSE / Yes, No." Controls the transmit rate when transmitting in the "RS232 Transmit" function. If the setting is "YES," there will be a delay of at least 4 ms between each byte transmitted. This will reduce throughput to less than 250 bytes per second which should prevent MUSE system overruns.

New Setup Question for Disabling Auto-Gain Change

- The question "Disable Automatic Gain Check" has been added to the Miscellaneous (Misc) Setup menu. If this questions is answered "YES," the questions "Change gain from 10mm/mV to 5mm/mV?" and "Change gain from 5mm/mV to 10mm/mV?" will not appear.

Rezero Commands Deleted

- Rezero commands are no longer sent to the acquisition module when an AM-2 acquisition module or AM-3 acquisition module is used. The MAC PC electrocardiograph now uses the same method as MAC 15 electrocardiograph to track the dc offset. This will eliminate the spaces that are seen in all leads when a lead is disconnected.

ECG Retrieval Problem Fixed

- Previous versions of software would occasionally plot the wrong ECG in Reverse Transmit (Store and Plot) and the ECG Editor. This problem has been fixed.

ECG Editor Problem Fixed

- A date of earlier than 1970 is now rejected when editing the 'ECG taken date'.

  Earlier version software would hang up when the "Continue Editing?" question was answered with just a carriage return. This software version requires the "Yes" or "No" softkey to be selected.

Software/Hardware Configurations (Cont)

Software Version 007/ 107

EPROM Part Numbers

Both software versions operate in the same manner. The difference relates to the size of the EPROMs in which the information is stored.

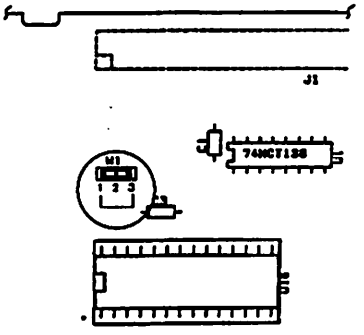
For 007, the following EPROMs are used.

On the processor pcb assembly, pn 85599-001:

U8 83350-007
U20 83351-007
U21 83352-007

On the EPROM expansion, modem, or analog/serial output pcb assemblies:

U4 83464-005
U16 83465-005

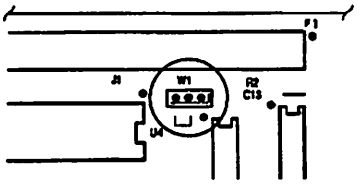


EPROM Expansion PCB Assembly

There is a jumper change required on the EPROM expansion and modem pcb assembly. On the EPROM expansion pcb assembly, the 2 outside pins on W1 should be shorted together. On the modem pcb assembly, the center pin and the pin nearest to U4 should be shorted together. (For details, see circled areas on illustration shown to left.)

For software version 107, the following EPROMs are used on the processor pcb assembly, pn 85599-002 and newer:

U8 83350-007
U20 83351-107
U21 83352-107



Modem PCB Assembly

Options and operating characteristic changes worth noting...

The storage of setup information date/time and ECGs was made more robust. Baseline drift and false "PAPER Release Open" messages were corrected.

Software/Hardware Configurations (Cont)

Software Version 008/ 108

EPROM Part Numbers

Both software versions operate in the same manner. The difference relates to the size of the EPROMs in which the information is stored.

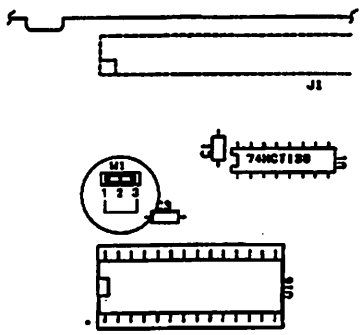
For 008, the following EPROMs are used.

On the processor pcb assembly, pn 85599-001:

U8 83350-007
U20 83351-008
U21 83352-008

On the EPROM expansion, modem, or analog/serial output pcb assemblies:

U4 83464-008
U16 83465-008

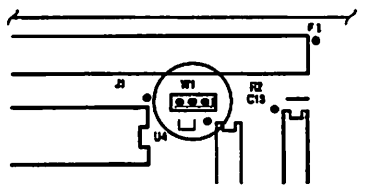


EPROM Expansion PCB Assembly

There is a jumper change required on the EPROM expansion and modem pcb assembly. On the EPROM expansion pcb assembly, the 2 outside pins on W1 should be shorted together. On the modem pcb assembly, the center pin and the pin nearest to U4 should be shorted together. (For details, see circled areas on illustration shown to left.)

For software version 108, the following EPROMs are used on the processor pcb assembly, pn 85599-002 and newer:

U8 83350-007
U20 83351-108
U21 83352-108



Modem PCB Assembly

Options and operating characteristic changes worth noting...

This software version supports the use of the AM-4 acquisition module with the unit. MAC PC electrocardiograph CAPOC units still require the AM-3 acquisition module.

Acquisition Module Product Summary

Introduction

The summarized information on the following pages will help solve problems occurring because the 'wrong' acquisition module is being used.

Many problems relating to acquisition modules occur because the 'wrong' acquisition module is being used with a particular product or for a particular application. To aid in troubleshooting this kind of problem, the following information has been summarized for each version of acquisition module that has been built:

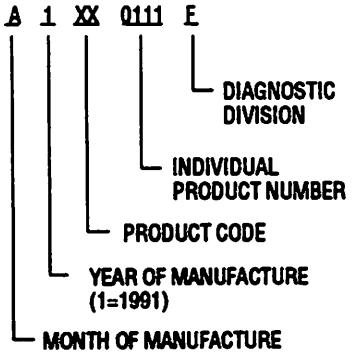
- product name, product code, and production serial numbers covering life span of acquisition module,
- part numbers associated with the various versions of the acquisition module, ie exercise, resting, English, German, etc,
- product configuration, ie hardware and software,
- product compatibilities, ie which product the acquisition module was designed to be used with, and
- option compatibilities, ie which options, analog output, XYZ leads, vector display, etc, the acquisition module supports.

Each acquisition module is identified by a unique multi-character serial number.

Each acquisition module is identified by a unique multi-character serial number located on the bottom of the unit or on the back of new acquisition modules. The typical serial number contains 9 characters but may contain up to 11. (Prior to 1990, the serial number contained only the first 8 characters, reading left to right, as described below.)

The basic 9 characters are used to identify the product (product code), time of manufacture, product sequential number, and division identifier (diagnostic, monitoring, etc).

The last 2 characters provide additional description, if necessary. For example, unique device characteristics (alterations to standard products, refurbished equipment, etc) are identified by the last 2 characters in an 11 character serial number.



The first character is a letter representing the month of manufacture. January is represented by the letter A, February by B, and so forth. To avoid confusion with the number 1, the letter I is not used in the serial number.

The product code for an AM-4 acquisition module is LD. LE is the product code for the AM-3 acquisition module. (Refer to the following pages for information on other acquisition modules.) The sequence and meaning of each position is shown to the left.

Original MAC Acquisition Module Product Summary

Product Serial Code

L6

Duration in Production

May, 1985 (E5) thru June, 1987 (F7)

Part Numbers and Descriptions

9488-210 Resting, English, AHA (10)
9488-311 Resting, German, IEC (10)
9488-310 Resting, English, IEC (10)
9488-312 Resting, French, IEC (10)
9537-210 Exercise, English, AHA (10)
9488-313 Resting, Italian, IEC (10)
9537-310 Exercise, English, IEC (10)
9488-314 Resting, Spanish, IEC (10)

Product Configuration Description

85584-001 Digital Front End PCB Assembly with pn 83349-001 EPROM.
85585-001 Analog Front End PCB Assembly
Units shipped from August 1985 (H5) thru February 1986 (B6) do not have leadwire extraction tool and plastic.
All units shipped with nonresistive leadwires (pn 9488-90X).

Product Compatibilities

MAC 12 (August 1985) – Yes
MAC PC (November 1985) – Yes
CASE 12 (September 1986) – Requires pn 83349-001E EPROM and conformal coat of pn 85585-001 analog front end pcb assembly; effective September, 1986 (I6).
MAC PC Cellular (November 1988) – No
MAC 6 (December 1988) – No
MAC 15 (December 1988) – Yes
MAX-1 (Spring, 1989) – No
CASE 15 (July 1989) – Requires pn 83349-001E EPROM and conformal coat of pn 85585-001 analog front end pcb assembly; effective September, 1986 (I6).
CENTRA (March 1990) – Requires pn 83349-001E EPROM and conformal coat of pn 85585-001 analog front end pcb assembly; effective September, 1986 (I6).
MAC VU (August 1991) – No

Option Compatibilities

MAC PC Analog Output Option – Requires pn 83349-002 EPROM and MAC PC upgraded with version 005/105 software.
Auxiliary Leads (A1, A2, A3, A4) – No
Pediatric Leads (V3R, V4R, V7) – No
XYZ Leads – No
Vector Display – No
Enhanced Pacemaker Detection – No
High-Resolution – No
Pacemaker Analysis – No

AM-1 Acquisition Module Product Summary

Product Serial Code

L6

Duration in Production

July, 1987 (G7) thru December, 1987 (M7)

Part Numbers and Description

9488-211 Resting, English, AHA (10)
9537-211 Exercise, English, AHA (10)
9488-319 Resting, International, IEC (10)
9537-311 Exercise, International, IEC (10)

Product Configuration Description

85584-001 Digital Front End PCB Assembly with pn 83349-001 EPROM.
85585-002 Analog Front End PCB Assembly
The pn 85585-002 analog front end pcb assembly features both digital sampling high frequency noise filters.
All units shipped with nonresistive leadwires (pn 9488-90X).

Product Compatibilities

MAC 12 (August 1985) – Yes
MAC PC (November 1985) – Yes
CASE 12 (September 1986) – Yes
MAC PC Cellular (November 1988) – No
MAC 6 (December 1988) – No
MAC 15 (December 1988) – Yes
MAX-1 (Spring 1989) – No
CASE 15 (July 1989) – Yes
CENTRA (March 1990) – Yes
MAC VU (August 1991) – No

Option Compatibilities

MAC PC Analog Output Option – Requires pn 83349-002 EPROM and MAC PC upgraded with version 005/105 software.
Auxiliary Leads (A1, A2, A3, A4) – No
Pediatric Leads (V3R, V4R, V7) – No
XYZ Leads – No
Vector Display – No
Enhanced Pacemaker Detection – No
High-Resolution – No
Pacemaker Analysis – No

AM-1M Acquisition Module Product Summary

Product Serial Code	L6
Duration in Production	Factory Refurbish
Part Numbers and Description	9488-212 Resting, English, AHA (10) 9537-212 Exercise, English, AHA (10)
Product Configuration Description	85584-003 Digital Front End PCB Assembly with pn 83349-001 EPROM or pn 85584-004 Digital Front End PCB Assembly (with pn 83349-002 EPROM) 85801-001 Analog Front End PCB Assembly Artwork clean-up of pn 85585-002 Analog Front End PCB Assembly, adds digital sampling and high frequency noise filters, improves defibrillator overload. All units shipped with nonresistive leadwires (pn 9488-90X).
Product Compatibilities	MAC 12 (August 1985) – Yes MAC PC (November 1985) – Yes CASE 12 (September 1986) – Yes MAC PC Cellular (November 1988) – No MAC 6 (December 1988) – No MAC 15 (December 1988) – Yes MAX-1 (Spring 1989) – No CASE 15 (July 1989) – Yes CENTRA (March 1990) – Yes MAC VU (August 1991) – No
Option Compatibilities	MAC PC Analog Output Option – Units reworked as of November 1988 (L8) include the pn 83349-002 EPROM on the pn 85584-004 digital front end pcb assembly as standard. The MAC PC still requires version 005/105 software. Auxiliary Leads (A1, A2, A3, A4) – No Pediatric Leads (V3R, V4R, V7) – No XYZ Leads – No Vector Display – No Enhanced Pacemaker Detection – No High-Resolution – No Pacemaker Analysis – No

AM-2 Acquisition Module Product Summary

Product Serial Code	L4
Duration in Production	August 1987 (H7) and newer
Part Numbers and Description	9488-214 Resting, English, AHA (10) 9537-214 Exercise, English, AHA (10) 9488-215 Cellular, English, AHA (10) 9537-314 Exercise, International, IEC (10) 9488-614 Resting, International, IEC (10) 9537-215 MAX-1, English, AHA (10) 9537-315 MAX-1, International, IEC (10)
Product Configuration Description	85691-001 Analog ECG Acquisition PCB Assembly 85692-002 Digital ECG Acquisition PCB Assembly with pn 83585-001 EPROM thru October 1988 (K8); phase-in pn 83585-002 EPROM in November 1988 (L8). Supports 16-lead data acquisition thru the use of optional leadwire sets for XYZ leads/vector display, auxiliary leads (A1, A2, A3, A4), or pediatric leads (V3R, V4R, V7). Shipped with pn 9566-90X resistive leadwires from August 1987 (H7) thru December 1988 (M8) inclusive. Effective January 1989 (A9), use pn 9488-90X nonresistive leadwires for all configurations.
Product Compatibilities	MAC 12 (August 1985) – Requires MAC 12 version 003 software or higher and RAM to acquire 14-lead data. MAC PC (November 1985) – Yes CASE 12 (September 1986) – Requires CASE 12 version 003 software or higher. MAC PC Cellular (November 1988) – Use pn 9488-215 only. MAC 6 (December 1988) – Yes MAC 15 (December 1988) – Yes MAX-1 (Spring 1989) – Requires pn 83585-002 software [standard in December 1988 (M8) and newer AM-2's]. Use pn 9537-215 or pn 9537-315 only. CASE 15 (July 1989) – Yes CENTRA (March 1990) – Yes MAC VU (August 1991) – No
Option Compatibilities	MAC PC Analog Output Option – Requires MAC PC version 005/105 software and the AM-2 software must be any version except pn 83585-002. Auxiliary Leads (A1, A2, A3, A4) – Yes Pediatric Leads (V3R, V4R, V7) – MAC 12/15 supported in version 003 software. CASE 12/15 does not support pediatric analysis. XYZ Leads – Yes Vector Display – Requires MAC 12/15 version 004N or later software. Enhanced Pacemaker Detection – No High-Resolution – No Pacemaker Analysis – No

AM-3 Acquisition Module Product Summary

Product Serial Code

L9

Duration in Production

September, 1988 (J8) and newer (As of August 1989, H9, these are replaced by LE product code.)

Part Numbers and Description

9488-217 Resting, High-Resolution, English, AHA (14)
9488-218 Resting, Pacemaker, English, AHA (14)
9488-617 Resting, High-Resolution, International, IEC (14)
9488-618 Resting, Pacemaker, International, IEC (14)

Product Configuration Description

All configurations are equipped with 14 leadwires with H, E, I, and M being standard. All units are shipped with pn 9488-90X nonresistive leadwires. The following hardware configurations are mutually exclusive:

High-Resolution

85691-003 Analog ECG Acquisition PCB Assembly
85692-004 Digital ECG Acquisition PCB Assembly

Pacemaker

85691-004 Analog ECG Acquisition PCB Assembly
85692-004 Digital ECG Acquisition PCB Assembly

Product Compatibilities

MAC 12 (August 1985) – MAC 12 will acknowledge this AM-3 version for 12 lead ECG's and auxiliary lead acquisition. Upgrade software to "005" for either high-resolution or pacemaker analysis.
MAC PC (November 1985) – No
CASE 12 (September 1986) – No
MAC PC Cellular (November 1988) – No
MAC 6 (December 1988) – MAC 6 will acknowledge this AM-3 version for 12 lead ECG's only.
MAC 15 (December 1988) – Yes
MAX-1 (Spring, 1989) – No
CASE 15 (July 1989) – Yes
CENTRA (March 1990) – No
MAC VU (August 1991) – No

Option Compatibilities

MAC PC Analog Output Option – No
Auxiliary Leads (A1, A2, A3, A4) – Yes
Pediatric Leads (V3R, V4R, V7) – Yes
XYZ Leads – Yes
Vector Display – Yes
Enhanced Pacemaker Detection – No
High-Resolution – Use pn 9488-217 or pn 9488-617 only.
Pacemaker Analysis – Use pn 9488-218 or pn 9488-618 only.

Enhanced AM-3 Acquisition Module Product Summary

Product Serial Code

LE

Duration in Production

August 1989 (H9) and newer

Part Numbers and Description

9488-701 Resting, Standard, AHA
9488-702 Resting, Standard, IEC
9488-703 Resting, High-Resolution, AHA
9488-704 Resting, High-Resolution, IEC
9488-705 Resting, Pacemaker, AHA
9488-706 Resting, Pacemaker, IEC
9488-707 Resting, Cellular, AHA
9488-708 Resting, Cellular, IEC
9488-709 Resting, Bipolar-XYZ High-Resolution, AHA
9488-710 Resting, Bipolar-XYZ High-Resolution, IEC

9537-701 Exercise, Standard, AHA
9537-702 Exercise, Standard, IEC
9537-703 Exercise, High-Resolution, AHA
9537-704 Exercise, High-Resolution, IEC
9537-705 Exercise, Pacemaker, AHA
9537-706 Exercise, Pacemaker, IEC
9537-707 Exercise, MAX-1, AHA
9537-708 Exercise, MAX-1, IEC
9537-709 Exercise, Bipolar-XYZ High-Resolution, AHA
9537-710 Exercise, Bipolar-XYZ High-Resolution, IEC

Product Configuration Description

All configurations are capable of 14-lead acquisition. All units are shipped with pn 9488-90X nonresistive leadwires.

Standard

85691-005 Analog ECG Acquisition PCB Assembly
85692-005 Digital ECG Acquisition PCB Assembly

High-Resolution

85691-006 Analog ECG Acquisition PCB Assembly
85692-006 Digital ECG Acquisition PCB Assembly

Pacemaker

85691-007 Analog ECG Acquisition PCB Assembly
85692-006 Digital ECG Acquisition PCB Assembly

Bipolar-XYZ High-Resolution

85691-008 Analog ECG Acquisition PCB Assembly
85692-006 Digital ECG Acquisition PCB Assembly

Product Compatibilities

MAC 12 (August 1985) – Yes
MAC PC (November 1985) – Yes (701 or 702 only)
CASE 12 (September 1986) – Yes
MAC PC Cellular (November 1988) – Yes (pn 9488-707, pn 9488-708, pn 9537-701, and pn 9537-702 only)
MAC 6 (December 1988) – Yes
MAC 15 (December 1988) – Yes
MAX-1 (Spring, 1989) – Yes
CASE 15 (July 1989) – Yes
CENTRA (March 1990) – Yes
MAC VU (August 1991) – No

Enhanced AM-3 Acquisition Module Product Summary (Cont)

Option Compatibilities

MAC PC Analog Output Option – Yes
Auxiliary Leads (A1, A2, A3, A4) – Yes
Pediatric Leads (V3R, V4R, V7) – Yes
XYZ Leads – Yes
Vector Display – Yes
Enhanced Pacemaker Detection – Yes
High-Resolution – Yes (703 or 704 only)
Pacemaker Analysis – Yes (705 or 706 only)

AM-4 Acquisition Module Product Summary

Product Serial Code LD

Duration in Production August 1991

Part Numbers and Description

900183-001	Resting, 10-Leadwire, AHA, MAC 6/PC (w/Host Cable pn 700044-003)
900183-002	Resting, 10-Leadwire, IEC, MAC 6/PC (w/Host Cable pn 700044-003)
900183-003	Resting, 14-Leadwire, AHA, MAC 15 (w/Host Cable pn 700044-003)
900183-004	Resting, 14-Leadwire, IEC, MAC 15 (w/Host Cable pn 700044-003)
900183-005	Resting, 14-Leadwire, AHA, MAC VU (w/Host Cable pn 700044-005)
900183-006	Resting, 14-Leadwire, IEC, MAC VU (w/Host Cable pn 700044-005)
900183-007	Resting, 10-Leadwire, AHA, MAC PC Cellular (w/Host Cable pn 700044-003)
900183-008	Resting, 10-Leadwire, IEC, MAC PC Cellular (w/Host Cable pn 700044-003)
900184-001	Stress, 10-Leadwire, AHA, MAX-1 (w/Host Cable pn 700044-001)
900184-002	Stress, 10-Leadwire, IEC, MAX-1 (w/Host Cable pn 700044-001)
900184-003	Stress, 14-Leadwire, AHA, CASE 15/CENTRA (w/Host Cable pn 700044-002)
900184-004	Stress, 14-Leadwire, IEC, CASE 15/CENTRA (w/Host Cable pn 700044-002)
900184-005	Stress, 14-Leadwire, AHA, MAC VU (w/Host Cable pn 700044-005)
900184-006	Stress, 14-Leadwire, IEC, MAC VU (w/Host Cable pn 700044-005)
900184-007	Stress, 10-Leadwire, AHA, Sensor (w/Host Cable pn 700044-001)
900184-008	Stress, 10-Leadwire, IEC, Sensor (w/Host Cable pn 700044-001)

Product Configuration Description

800064-001	Analog ECG Acquisition PCB Assembly
800066-001	Digital ECG Acquisition PCB Assembly

AM-4 Acquisition Module Product Summary (Cont)

Product Compatibilities

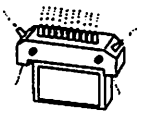
MAC 12 (August 1985) – No
MAC PC (November 1985) – Yes
CASE 12 (September 1986) – No
MAC PC Cellular (November 1988) – No
MAC 6 (December 1988) – Yes
MAC 15 (December 1988) – No
MAX-1 (Spring, 1989) – Yes
CASE 15 (July 1989) – No
CENTRA (March 1990) – No
MAC VU (August 1991) - Yes

Option Compatibilities

MAC PC Analog Output Option – Yes
Auxiliary Leads (A1, A2, A3, A4) – Yes
Pediatric Leads (V3R, V4R, V7) – Yes
XYZ Leads – Yes
Vector Display – Yes
Enhanced Pacemaker Detection – Yes
High-Resolution – Yes
Pacemaker Analysis – No

AM-3/AM-4 Acquisition Module Compatibility

The table below shows which Marquette Electronics' products can be used with the AM-3 acquisition module and which can be used with the new AM-4 acquisition module. Future software revisions will allow more products to use the AM-4 acquisition module.

	AM-3 	AM-4 
Electrocardiographs		
MAC PC	Use an AM-3 acquisition module for MAC PC electrocardiographs using software versions 008A, 108A or earlier.	Use an AM-4 acquisition module for MAC PC electrocardiographs using software versions 008A, 108A or later.
MAC PC Cellular	Use an AM-3 acquisition module for MAC PC Cellular electrocardiographs using software versions 008A, 108A or earlier.	Use an AM-4 acquisition module for MAC PC Cellular electrocardiographs using software versions 008A, 108A or later.
MAC 6	Use an AM-3 acquisition module for MAC 6 electrocardiographs using software versions 005A or earlier.	Use an AM-4 acquisition module for MAC 6 electrocardiographs using software versions 005A or later.
MAC 12/15	Use an AM-3 acquisition module for MAC 12/15 electrocardiographs using software versions 008B, 108B or earlier.	Use an AM-4 acquisition module for MAC 12/15 electrocardiographs using software versions 008A, 108A, or later.
MAC VU	Do NOT use an AM-3 acquisition module with the MAC VU electrocardiograph.	Use an AM-4 acquisition module for MAC VU electrocardiographs using software versions 001A or later.
Stress Systems		
MAX-1	Use an AM-3 acquisition module for MAX-1 stress systems.	Do NOT use an AM-4 acquisition module with the MAX-1 stress system.
CASE 12	Use an AM-3 acquisition module for CASE 12 stress systems.	Do NOT use an AM-4 acquisition module with the CASE 12 stress system.
CASE 15	Use an AM-3 acquisition module for CASE 15 stress systems.	Do NOT use an AM-4 acquisition module with the CASE 15 stress system.

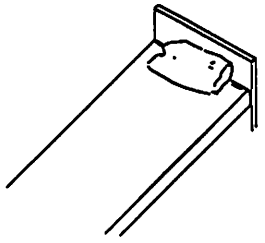
Equipment with CAPOC software should always use an AM-3 acquisition module.

Pace AM-3 acquisition modules are required for Pacemaker applications. The AM-4 acquisition module does not support Pacemaker application.

Poor Quality ECG Traces

Poor quality ECG traces mean excessively noisy data. Several things can contribute to noisy data. These paragraphs describe some of the things to look for when troubleshooting this problem.

Environment



The environment (or the location) in which the MAC PC electrocardiograph is operating can affect the quality of the ECG data.

- Move the acquisition module as far away from the unit as possible. This will help to determine if the electrocardiograph itself is generating the electromagnetic noise (possibly caused by a noisy power supply).
- Move the unit to another location to determine if there might be excessive electromagnetic noise in the original location.

Patient Preparation

Patient preparation is very important. Check the following elements of adequate patient preparation.

⚠WARNING

Ensure that the conductive parts of lead electrodes and associated connectors do not contact other conductive parts, including earth. Otherwise, injury to the patient may occur.

M15287-4A

Electrodes

Follow these guidelines when using electrodes and adapters.

- Do not use electrodes after their shelf life has expired. Make sure to follow application instructions for the type of electrode being used. Wet gel and solid gel electrodes have entirely different properties and, thus, different methods of application.
- Use the right size adapter for your banana pin leadwire. Forcing an adapter that is too small will crush the banana pin and cause trace disruption.
- Adapters should be right side up so metal contacts metal to ensure conductivity. Avoid contact of the metal adapter with electrode gel. Dried gel deposits will insulate rather than conduct the ECG signal.
- Adapters should not be mixed. Replace damaged or worn adapters to maintain good signal quality.

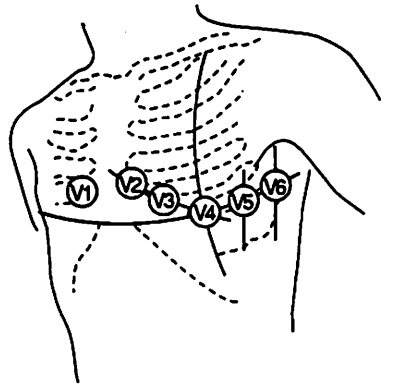
Poor Quality ECG Traces (Cont)

Placing Chest Electrodes

Electrode site should be cleaned with mild soap and water or alcohol. Sometimes shaving the hair from the electrode site is necessary.

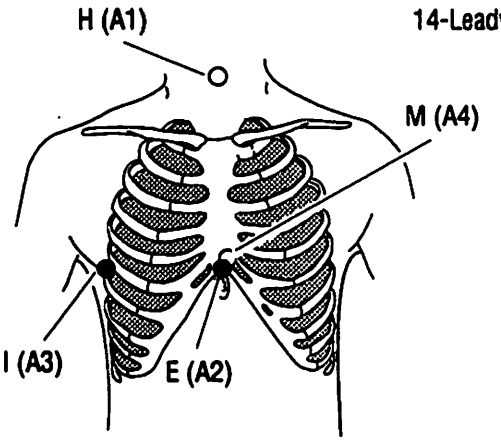
The standard placement for chest electrodes for both 10- and 14-leadwire acquisition modules is shown below. The placement of auxiliary and pediatric electrodes when using 14-leadwire acquisition modules is shown also.

10- and 14-Leadwire Acquisition Modules

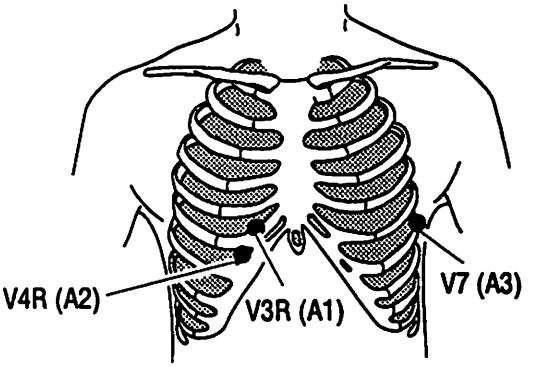


Standard Chest Electrode Placement

14-Leadwire Acquisition Modules



Auxiliary Electrode Placement



Pediatric Electrode Placement

Placing Limb Electrodes

The placement of the limb electrodes may vary. The signal taken from the shoulder is virtually the same as that from the wrist. Likewise the signal taken from the groin is virtually the same as that taken from the ankle. Generally, the electrode should not be placed on the torso for a resting ECG.

Placing Limb Plate Electrodes

If limb plate electrodes are used, they should be placed on the inside of the arm several inches up from the wrist and on the leg several inches up from the ankle.

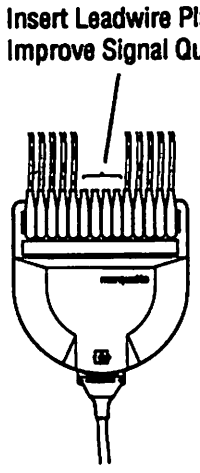
Poor Quality ECG Traces (Cont)

Placing Other Types of Electrodes

If Welsh (suction), tab (Silver Mactrode), or snap-type pregelled electrodes are used, it is recommended that the arm electrodes be placed on the upper arm (outer shoulder) and the leg electrodes be placed just above the knee or mid-calf. This placement will minimize the effect of muscle tremor since the electrodes are not located over the tendons in the lower arm and leg.

Acquisition Module

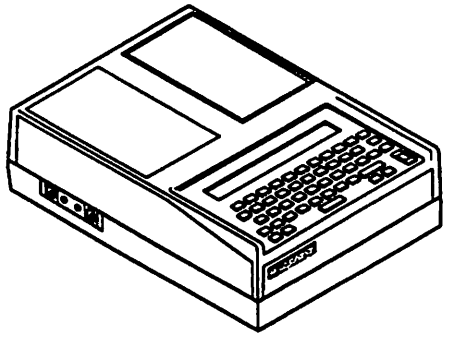
The acquisition module, leadwires, and connector cable can all add to noisy or irregular ECG tracings.



- To improve signal quality, always insert a leadwire plug in the AM-4 acquisition module when a leadwire is not attached to a patient.
- Visually inspect all leadwires. Check the integrity of the leadwire connection to the acquisition module.
- Check resistance of the signal connections to verify that the leadwire is not broken internally. Check resistance between signal connection and the shielding to verify no leakage.
- Visually inspect the connector cable and make sure all connections are intact and tight.
- Use another acquisition module to help isolate the problem. If the acquisition module is defective, refer to the troubleshooting paragraphs that deal with the acquisition module.

MAC PC Electrocardiograph

Use the software in the unit, to resolve the conditions causing excessive lead-fail/bad lead error messages.



- If the QC baseline drift and QC muscle tremor options were selected under the *Cart Setup* menu, the MAC PC electrocardiograph displays greater sensitivity, ie the unit will display a 'bad lead' error message if the threshold for either QC baseline drift or QC muscle tremor is exceeded. For most applications, this may be more sensitivity than is necessary.

  Select *No*, for the QC baseline drift and QC muscle tremor prompts under the *Cart Setup* menu. This eliminates any error messages caused by excessive QC baseline drift or QC muscle tremor.

Lead Formation

Introduction

Ensuring adequate patient preparation is an important part of troubleshooting.

Since the purpose of the MAC PC electrocardiograph is to obtain a multi-lead electrocardiogram (ECG), it is a good idea to review the elements that contribute to producing a good quality ECG report, ie, the environment, patient preparation, and acquisition module. (Ensuring adequate patient preparation is an important part of troubleshooting.) Verifying that all the factors in obtaining an ECG have been properly addressed will reduce the need to troubleshoot these "obvious" problems. (See paragraphs titled "Poor Quality ECG Traces" in this chapter.)

Typically, the first step in troubleshooting will be to obtain an ECG report on the failing unit using your simulator. You should have a copy of a good report from your simulator as a handy reference. This report is very useful when trying to determine if the data on a report from a unit in question is correct.

Definitions

Often there is confusion over the terms used when describing signals used in ECGs. To produce a 12-lead ECG, 10 electrodes are attached to the patient, 1 to each of the 4 limbs (limb leads), and 6 to the chest (precordial leads). The right leg electrode labeled RL returns a signal to the patient which is used to lessen interference. The remaining 9 electrodes are combined to form 12 leads recorded on the ECG.

Electrode Sites Electrode sites are those places where electrodes are attached to the patient. They are typically identified as RA, LL, V1, V5, etc.

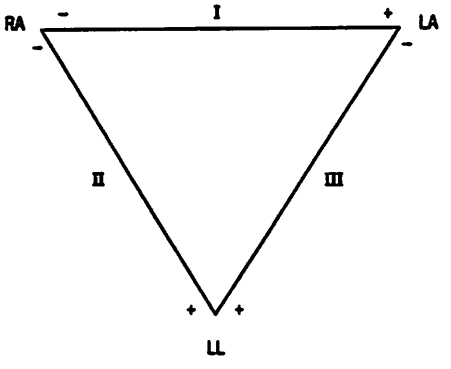
Leadwire A leadwire connects an electrode to the circuits of a machine. Leadwires are often coded with respect to the electrode sites.

Lead Leads are combinations of 2 or more signals taken from the electrode sites. They are identified as I, II aVF, V1, V5, Z, etc.

Lead Formation (Cont)

Definitions (Cont)

Following are the definitions of the standard 12 leads. To avoid confusion in the formulas below, V1 through V6 represent chest electrode sites V1 through V6, respectively.



Einthoven's Triangle

LEAD	COMBINED SIGNALS
I	LA – RA
II	LL – RA
III	LL – LA
aVR	$RA - \frac{LA + LL}{2}$
aVL	$LA - \frac{RA + LL}{2}$
aVF	$LL - \frac{RA + LA}{2}$
V1	$V1 - \frac{RA + LA + LL}{3}$
↓	↓
V6	$V6 - \frac{RA + LA + LL}{3}$

Electrode sites and leads are different even though they share the same name.

Remember that there is a difference between electrode site V1 and lead V1 shown on the thermal paper. As defined above, lead V1 is the signal from site V1 but with the average of the limb signals subtracted from it.

The right leg signal is used to suppress noise in the other leads.

In Marquette electrocardiographs the right leg (RL) electrode has a signal applied to it by the equipment. This signal is used to suppress noise and interference. If there is a problem with the RL electrode, the ECG data taken will display excessive 50 or 60 Hz noise, or the display will be a flat line. Note, the exact position of the right leg (RL) electrode is not critical. It is placed on the right leg by convention.

The acquisition module acquires data from an electrode site; the electrocardiograph then performs the mathematics to construct any given lead.

To summarize, the acquisition module acquires data from the electrode sites and delivers leads I and II directly to the electrocardiograph. The electrocardiograph then performs the mathematics to construct any given lead:

Lead		Calculations
III	=	II – I
aVR	=	$\frac{(I + II)}{2}$
aVL	=	$\frac{(I - III)}{2}$
aVF	=	$\frac{(II + III)}{2}$

The MAC PC electrocardiograph is equipped for 12 lead (10-leadwire) operation only. The MAC PC electrocardiograph does not perform vectorcardiography (vector loops), high-resolution (late potentials) analysis, or pacemaker analysis.

Static Discharge Problems

Introduction

Static discharge can cause the loss of setup values and blanking of the lcd.

There are several examples of the problems caused by static discharge. There may be loss of setup values. The lcd may blank or eventually burn out.

Most problems are caused by the excessive buildup of static charges which are not being discharged properly through the unit. For example, static may be discharging through an IC on a printed circuit board assembly causing it to function improperly. Many of the semiconductor devices used in the unit are sensitive to static discharge.

Static charges can build up from movement of the thermal paper over the writer surfaces, or if the unit is mounted on a cart, rolling the cart over carpeted surfaces.

The troubleshooting information on this problem begins with the basic things to do to control static discharge damage. This is followed by specific modifications that can be made on the unit.

Static Discharge Problems (Cont)

Controlling Electrostatic Discharge Damage

The equipment makes extensive use of CMOS components. CMOS components are used because they are more safe from noise and consume less power than standard TTL or NMOS components. However, CMOS components are more easily damaged by electrostatic discharge (ESD) damage than other semiconductors.

ESD damage, usually a subtle weakening of semiconductor junctions, can range from corruption of digital memory to catastrophic failure, making a component or a number of components permanently unusable. Although it is more common for CMOS components to fail from ESD damage, *no semiconductor device is completely safe from ESD damage.*

The inputs and outputs of all of the equipment components are protected from ESD damage, so they are no more susceptible to ESD damage during normal operation than any other device. However, when the equipment components are being serviced, the components are exposed to several sources of static electricity, ranging from human hands to improperly grounded test equipment. For this reason, it is recommended that all service workstations be as static-free as possible.

Although these guidelines cannot ensure a 100% ESD-free workstation, they will help reduce the sources of ESD damage.

The following guidelines can help make your workstation more resistant to the damage that can be caused by static electricity.

- Discharge any static charge you may have built up before handling semiconductors or assemblies containing semiconductors.
- A grounded, antistatic wristband or heelstrap should be worn at all times when repairing assemblies containing semiconductors.
- Use only properly grounded soldering and test equipment.
- Use a static-free surface when working on assemblies containing semiconductors.
- Do not remove semiconductors or assemblies containing semiconductors from antistatic containers (bags) until needed.
- Make sure power to an assembly is turned off before removing or inserting a semiconductor.
- Do not slide semiconductors or assemblies containing semiconductors across any surface.
- Do not touch semiconductor leads unless absolutely necessary.
- Semiconductors and assemblies containing semiconductors should be stored only in antistatic bags or boxes.

Static Discharge Problems (Cont)

Grounding the LCD

Static discharge can cause blanking of the lcd.

Before beginning, write down/print out all setup information. Transmit stored ECGs.

See the paragraphs titled "Installing New Software" in this chapter for detailed instructions on opening, closing, and reprogramming the unit.

Static discharge may cause blanking or burning out of the lcd.

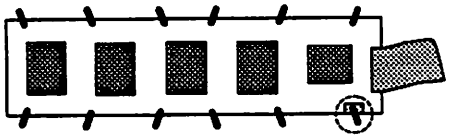
Since the battery cable must be disconnected during this procedure, all stored ECGs should be transmitted (if that is what is normally done with the ECG data) and all setup information written down. (With 006/106 and later version software, the setup information can be printed out. Select "Print" under Cart Setup.) After the unit reassembled, this setup information will have to be reprogrammed.

The lcd pcb assembly should be removed form the MAC PC electrocardiograph to perform the modification.

- In order to control static-discharge damage, be sure to discharge any static charge you may have built up before beginning this procedure. Wear a grounded, anti-static strap while carrying out this upgrade. Work on a static-free surface.
- Open the unit. (See "Opening the Unit for Service" in chapter 3, Maintenance, for disassembly and reassembly instructions.)
- There are 12 black lcd bezel mounting tabs. Locate the tab that has a gold-plated ground connection below it on the lcd pcb assembly (circled area in figure shown below.)
- This tab should be soldered to the gold-plated ground connection below it. If it is not soldered, replace it with a new lcd assembly, pn 88714-002.
- Due to possible existing component degradation from static discharge, do not solder the tab in the field. The placement units will have been soldered in production.
- Replace lcd pcb assembly in cover and secure with 4 corner screws, previously removed.
- Reconnect the lcd cable to J3 on the processor pcb assembly.
- Reconnect the battery cable, J9, on the processor pcb assembly.
- Closing the unit. (See "Basic Reassembly" in chapter 3, Maintenance, for instructions.)

NOTE

You MUST disconnect the battery cable from the processor pcb assembly first. Failure to do so could cause severe damage to the processor pcb assembly.



LCD Assembly

Reconnect J9 (battery cable) last.

Static Discharge Problems (Cont)

Adding the Current-Limiting PCB Assembly

The current-limiting pcb assembly isolates the 5-volt line on the keyboard—w/display assembly from the 5-volt line on the processor pcb assembly.

The lcd current-limiting pcb assembly, pn 403945-002, should be added to the processor pcb assembly, pn 85599-XXX, in the MAC PC electrocardiograph. This pcb assembly isolates the 5-volt line on the keyboard—w/display assembly from the 5-volt line on the processor pcb assembly. The lcd current-limiting pcb assembly can be used to reduce static susceptibility on any pn 85599-00X pcb assembly up to and including the 005 version. The pn 85599-006 and later version pcb assemblies include this improvement in the pcb design.

The lcd current-limiting pcb assembly is installed in J3 on the processor pcb assembly. After the modification is completed, the lcd cable, which was connected to J3 on the processor pcb assembly, is now connected to J1 on the lcd current-limiting pcb assembly.

NOTE

You MUST disconnect the battery cable from the processor pcb assembly first. Failure to do so could cause severe damage to the processor pcb assembly.

Open the unit. (See "Opening the Unit for Service" in chapter 3, Maintenance, for instructions.)

- Insert J2 of the current-limiting pcb assembly into J3 on the processor pcb assembly. The nylon standoff will rest on U35.
- Plug the lcd cable, previously removed, into J1 on the current-limiting pcb assembly.
- Reconnect battery cable, J9, on the processor pcb assembly.
- Before closing the unit, check to make sure that all cables/ harnesses are tucked out of the way and will not be crimped or pinched when the unit is closed.
- Reprogram the cart setup information. (See the paragraphs titled "Reprogramming the Unit" in chapter 3, Maintenenace, for instructions.)

Where to Go From Here

If this chapter fails to isolate or solve the problem, the following chapters further cover the troubleshooting and repair of the various assemblies in the unit.

- Chapter 5, Power Module
- Chapter 6, ECG Circuits
- Chapter 7, Writer 1
- Chapter 8, Writer 2
- Chapter 9, Modem

See chapter 11, Tech Memo Summary, for more troubleshooting information on all assemblies. Chapter 10, Parts Lists and Drawings, contains exploded views of all assemblies and part numbers for ordering replacement parts.

NOTES

Chapter 5
Power Module

Types of Power Modules

Introduction

Four different power modules have been used with the MAC PC electrocardiograph since its introduction. Following are brief descriptions of the power modules.

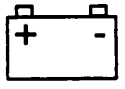
MAC PM Power Module

The original power module was produced from 1985 through June, 1987. It is marked *MAC PM* on the bottom. It does not have a power switch and its fuse is integral to the transformer (therefore can not be replaced).

PM-2 Power Module

This is an improved version of the original power module and has been used since June, 1987. The specifications are very similar to the original power module. One easy-to-spot difference between PM-2 power module and the original power module is the 2 LEDs in the case.

AC



One LED indicates that the PM-2 power module is plugged into an ac outlet. The other LED indicates that the PM-2 power module has been connected to the MAC PC electrocardiograph.

It also does not have a power switch and its fuse is also integral to the transformer (and therefore can not be replaced).

PM-3 Power Module

The PM-3 power module is designed for users who run the reverse transmission mode or the analog output option for extended periods of time (over 2 hours).

It is easily identified by its size (about half the size of the unit itself) and the fan at one end of the units metal cabinet. A power switch allows it to be turned off without disconnecting it from the ac outlet. It also has two 1 A fuses which are replaceable.

PM-4 Power Module

This power module is for MAC PC cellular electrocardiograph and should not be used with the MAC PC electrocardiograph.

MAC PM Power Module Troubleshooting and Repair

These power modules are usually replaced by PM-2 power module units.

MAC PM power modules are generally not repaired, but are exchanged for one of the later power modules.

If an exchange is made, the printed circuit board with the transformer is included. Note, that this exchange does not include the rubber shock mount boot surrounding the transformer. The cabling also is not included with the exchange.

Differences for 120 V and 240 V units.

Two circuit boards were used in the original MAC PM power module, one for 110 to 120 V and the other for 220 to 240 V. The difference between the 2 can be determined by the configuration of resistors R1, R2, and R3.

If only resistor R1 and resistor R3 are installed, then the circuit board is pn 85626-001. If only resistor R2 is installed, then the circuit board is pn 85626-002.

Early units may not have the rubber shock boot and the 2 studs securing the shock boot. The shock boot is pn 58163-001 and the 2 studs are pn 58164-001 (2 required).

Troubleshooting starts with a good ac outlet.

Disconnect the power module from the ac outlet and from the MAC PC electrocardiograph. Test the ac outlet to verify that it is wired properly. (Chapter 4, General Troubleshooting, provides a power source verification procedure.) Once the outlet is known to be good, connect the power module to it and proceed.

Measure the dc output at the end of the dc power supply cable.

Using a digital multimeter, measure the dc voltage at the output of the dc power supply cable at the end that connects to the unit. Use the outer ring of the cable connector as a ground reference. Measure the dc voltage inside the tip of the cable connector.

	Iout	
	150 mA	0 mA
MAC PM	27 V	27-30 V
PM-2	27 V	27-30 V

In a 120 V power module, the dc output should measure approximately 27 V. If the dc voltage is outside this range, you can replace the entire power module with all of the associated power cables or continue troubleshooting.

Even with correct dc voltage, the current output might not be sufficient in a defective MAC PM power module. Therefore, just measuring the dc voltage is not an adequate test.

Note, that it is quite possible that the correct dc voltage is present at the tip of the dc power supply cable but the power module is defective. When a defective power module is loaded, by connecting it to a MAC PC electrocardiograph, its output voltage might drop very low as current flows to power the MAC PC electrocardiograph.

If another power module is available, try connecting it to the MAC PC electrocardiograph and observe the battery charging. If the battery now charges, the original power module probably is defective. Replace the power supply pcb assembly, pn 85626-001, and the dc power supply cable assembly, pn 80630-001.

If a dc voltage is not present at the tip of the dc power supply cable, verify the ac power supply cable.

If no dc voltage is present at the tip of the dc power supply cable, the problem could be the ac power supply cable, an internal fuse, or maybe a failure on the power supply pcb assembly. The power module will have to be disassembled for further troubleshooting.

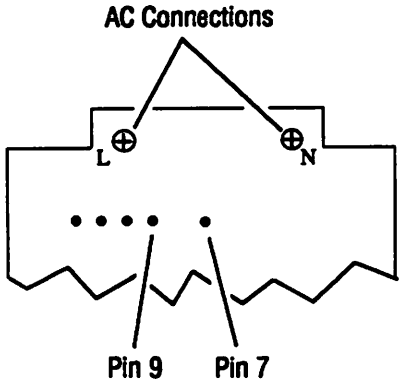
Disconnect the ac power supply cable from the ac outlet.

MAC PM Power Module Troubleshooting and Repair (Cont)

If a dc voltage is not present at the tip of the dc power supply cable, verify the ac power supply cable (cont).

Remove the base and cover of the power module. Note, that there are 2 screws on each side securing the cover.

The power supply pcb assembly will remain attached to the cover by 2 mounting studs attached to the cover and inserted into holes in the black rubber shock boot. To remove the circuit board from these 2 studs, hold the assembly by the shock boot and twist it away from the studs. This may require some force to accomplish. Pinch the shock boot while doing this to reduce the pressure exerted on the side of the cover.

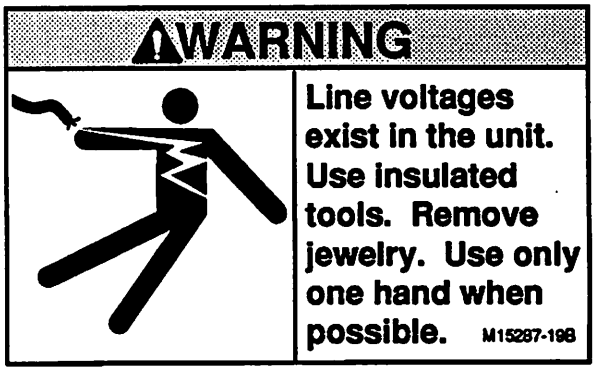


Lay the power supply pcb assembly on a work surface with its solder side facing up.

Check for an open fuse by measuring the resistance between pins 7 and 9 of the transformer.

If the resistance is greater than 2 ohms, the fuse is open and the power supply pcb assembly, pn 85626-001, should be replaced or exchanged.

If the resistance is less than 2 ohms, the fuse is okay and you can continue with troubleshooting.



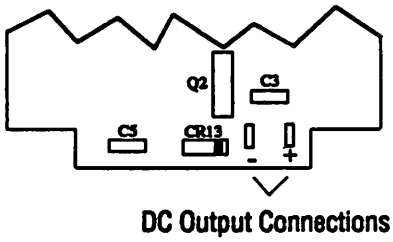
If the fuse is good, try measuring the ac voltage applied to the transformer.

Connect the ac power supply cable to the ac outlet.

Using a digital multimeter, measure the voltage across the ac connections on the power supply pcb assembly.

If the ac voltage is less than 110 V ac, replace the ac power supply cable, pn 80629-001. Unless the ac outlet was previously verified, it could also be the source of the problem.

If the applied ac voltage is within range, try measuring the dc output at the circuit board.



If the ac voltage is within the proper range (110 to 120 V), measure the dc output of the power supply pcb assembly. If the dc output measures approximately 27 V, replace the dc power supply cable, pn 80630-001.

Note, that the dc power supply cable is polarized. The terminals on top of the power supply pcb assembly are marked + and –. Also the conductor with the grooved insulation carries the + dc voltage.

If the dc voltage is not present at the terminals on the power supply pcb assembly, replace the assembly, pn 85626-001.

PM-2 Power Module Troubleshooting and Repair

Introduction

The PM-2 power module can be identified by the 2 LEDs in its cover. These LEDs indicate when the module is connected to the ac outlet and to the MAC PC electrocardiograph.

Troubleshooting starts with a good ac outlet.

Disconnect the PM-2 power module from the ac outlet and from the MAC PC electrocardiograph. Test the ac outlet to verify that it is wired properly. (Chapter 4, General Troubleshooting, provides a power source verification procedure.) Once the ac outlet is known to be good, connect the PM-2 power module to it and proceed.

Use the 2 LEDs to determine the probable failure.

Connect the PM-2 power module to a MAC PC electrocardiograph and observe the 2 LEDs in the PM-2 power module.

If both LEDs are on, then the PM-2 power module is working.

If the 2 LEDs in the PM-2 power module are lighted, there is ac power applied to the transformer and dc power being sent to the MAC PC electrocardiograph. This would imply that the PM-2 power module is working.

If the dc LED is off and the ac LED is on or flickering...

If the dc LED is off and the ac LED is on or flickering, replace the power supply pcb assembly, pn 85626-101, and the dc power supply cable, pn 80630-001.

If both LEDs are off...

If both LEDs are off, the PM-2 power module must be disassembled to test whether the ac power supply cable is defective or the fault is in the power supply pcb assembly.

Disconnect the ac power supply cable from the ac outlet.

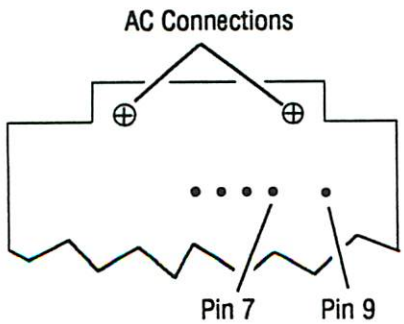
Remove the base and cover of the PM-2 power module. Note, that there are 2 screws on each side securing the cover.

Disassemble the PM-2 power module.

The power supply pcb assembly will remain attached to the cover by 2 mounting studs attached to the cover and inserted into holes in the black rubber shock boot. To remove the circuit board from these 2 studs, hold the assembly by the shock boot and twist it away from the studs. This may require some force to accomplish. Pinch the shock boot while doing this to reduce the pressure exerted on the side of the cover.

Check the internal fuse.

Check for an open fuse by measuring the resistance between pins 7 and 9 of the transformer.

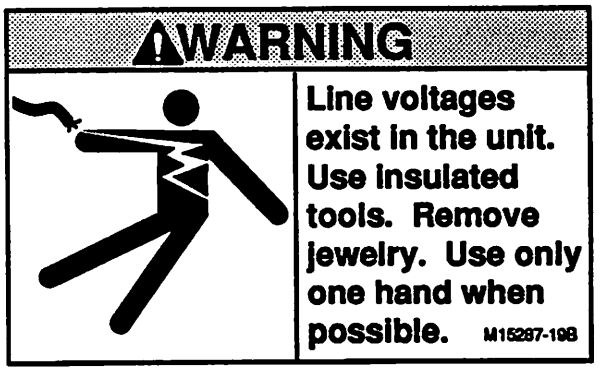


If the resistance is greater than 2 ohms, the fuse is open and the power supply pcb assembly, pn 85626-101, should be replaced or exchanged.

If the resistance is less than 2 ohms, the fuse is okay and you can continue with troubleshooting.

PM-2 Power Module Troubleshooting and Repair (Cont)

Check the ac input.



Connect the ac power supply cable to the ac outlet.

Using a digital multimeter, measure the ac voltage applied to the power supply pcb assembly.

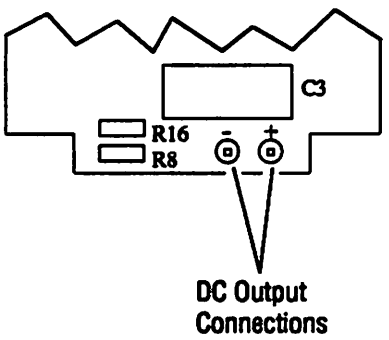
If the ac voltage on the power supply pcb assembly is within the proper range (110 to 120 V), continue troubleshooting the PM-2 power module.

If the ac voltage is not within the proper range, replace the ac power supply cable, pn 80629-001. Verify that the ac outlet is good before replacing the cable.

Lay the power supply pcb assembly on a work surface with its solder side facing up.

If the applied ac voltage is within range, try measuring the dc output at the circuit board.

If the ac voltage was within the proper range (110 to 120 V), measure the dc output of the power supply pcb assembly. If the dc output measures 27 V ±1 V, replace the dc power supply cable, pn 80630-001.



DC Output Connections

Note, that the dc power supply cable is polarized. The terminals on top of the power supply pcb assembly are marked + and –. Also the conductor with the grooved insulation carries the + dc voltage.

If the dc voltage is not present at the terminals on the power supply pcb assembly, replace the assembly, pn 85626-101.

PM-3 Power Module Troubleshooting and Repair

Introduction

The PM-3 power module is designed for users that require reverse transmission or the analog output to operate for extended periods of time. It has a much larger power supply. It also has replaceable fuses and a cooling fan, both of which help in troubleshooting and repair.

Troubleshooting starts with a good ac outlet.

Disconnect the PM-3 power module from the ac outlet and from the MAC PC electrocardiograph. Test the ac outlet to verify that it is wired properly. (Chapter 4, General Troubleshooting, provides a power source verification procedure.) Once the ac outlet is known to be good, connect the PM-3 power module to it and proceed.

If the cooling fan runs, there is ac power.

Apply power to the PM-3 power module. The cooling fan should be audible as it starts up and runs. If the fan does not run then:

- check the ac power supply cable, pn 80274-101, and
- check the 2 fuses located on the rear of the PM-3 power module.

Now check the dc output.

If the fan is running, measure the dc output from the PM-3 power module. Using a digital multimeter, measure the dc voltage across pins 3 and 4 of the dc power supply cable. It should be 27 V ±1 V.

If this voltage is not present, disconnect the dc power supply cable from the power module. Measure the dc output directly at the output connector on the PM-3 power module.

If the dc voltage is present and within range, replace the dc power supply cable, pn 80746-001. If the voltage is not present at the connector, replace the power supply pcb assembly, pn 6132-005.

PM-3 Power Module Vendor Change

The vendor for the power supply used in the PM-3 power module has been changed from Power One to Condor.

The new Condor power supply is compatible with the Power One supply.

The new Condor power supply is compatible with the Power One supply. However, the assembly part numbers have been changed to incorporate the new Condor power supply and power harness differences.

The Power One power supply assembly, pn 88853-001, was used in the MAC PC electrocardiograph's PM-3 power module. In the MAC PC electrocardiograph's PM-3 power module, the pn 88853-004 assembly replaces the pn 88853-001 assembly.

To install a 004 assembly in the PM-3 power module

When installing the 004 assembly in a PM-3 power module, you will have to solder the 2 leads from the S1 switch on the PM-3 power module to the transformer.

To replace a power supply

The wiring diagram of the Condor and a Power One supply are identical. You can replace the Condor supply with a Power One supply and vice versa by reconnecting the same color-coded wires between the transformer and the ac terminal block.

If replacing the Condor supply with a Power One supply, you should order the Power One power supply harness (pn 80562-003) at the same time. (Ordering a new harness will prevent the possibility of damaging the transformer terminals through overheating during soldering.)

Wiring Diagram

WIRE NO.	WIRE COLOR	WIRE TO
W4-1	WHT	PS1 T1-1
W4-2	BLK	PS1 T1-3
W4-5	WHT/GRY	PS1 T1-5
W4-4	WHT/RED	PS1 T1-4
W4-3	WHT/BLK	PS1 T1-2

Chapter 6
ECG Circuits

ECG Circuits

Introduction

ECG data is acquired and converted to digital data in the acquisition module.

This chapter addresses problems with ECG data acquisition and the quality of ECG data as it appears on the thermal paper. ECG data is acquired and converted to digital data in the acquisition module. It is then transmitted to the processor pcb assembly over a serial link. The processor pcb assembly analyzes the data and can transmit, print, or store it.

Handle the acquisition module with care to preserve its delicate electronic circuits.

Many of the hardware failures that occur are with the acquisition module, its cabling, and the leadwires. Operators should be cautioned that the acquisition module has delicate electronic circuits, including a crystal oscillator which will most likely fail if the acquisition module is dropped.

To begin troubleshooting, answer these questions first.

There are 2 general categories that ECG data problems fall into: noisy ECG data (including straight-lined ECG leads) and wrong ECG data.

Is the black cable connected securely to the acquisition module and the MAC PC electrocardiograph?

Each of these categories is considered separately in this chapter. First there are some preliminary steps to perform.

Is the thermal writer functioning properly?

- Confirm that the patient coiled cord is connected securely to the acquisition module and the MAC PC electrocardiograph.
- Confirm that the thermal writer is functioning properly. See chapter 7, Writer 1, and chapter 8, Writer 2, for writer operation.

Are the leadwires connected in the proper positions in the acquisition module?

- Inspect the leadwires to verify they are connected to the proper positions in the acquisition module.

Using a simulator for input, try to acquire, analyze, and print a report.

Connect the leadwires to a simulator and run a 12-lead report by pressing the [12] key. Pressing record ECG initiates the data acquisition, analysis, and plotting functions.

Carry a copy of a good 12-lead report from your own simulator to use as a handy troubleshooting aid.

You should have a copy of a good 12-lead report from your own simulator as a handy reference. This is very useful when trying to determine if the data is correct on a report.

Make sure the simulator and acquisition module are at least 2 feet from the MAC PC electrocardiograph and its power module. This will help avoid potential problems with 60-Hz interference from the power module and other environmental sources.

Observe the lcd for error messages. Override any error message by pressing [12] a second time. Turn the simulator off leaving the leadwires connected and run the hardware diagnostics labeled *FrntEnd*.

Using the Hardware Diagnostics

Use the built-in hardware diagnostics to check communication and noise levels.

Accessing the Hardware Diagnostics Menu

starting from the Main Menu,

press [⇧] + [F1 2]

to reach the System Functions Menu,

then press [F3 5]

for the Hardware Diagnostics Menu options.

Press [F3 5] for the *FrntEnd* Diagnostics Menu.

Before running the hardware diagnostic tests, confirm that the thermal writer is functioning properly. (For more information, see chapter 7, Writer 1, and chapter 8, Writer 2.) Several of the hardware diagnostic tests are designed to check the ECG circuits.

The Hardware Diagnostics Menu is reached from the Main Menu by holding down the shift key and pressing the F1-2 key. Once the System Functions Menu is displayed, press the F3-5 key to select the hardware diagnostics.

Press the F3-5 key, *FrntEnd*, to display the acquisition module Diagnostics Menu. Contained in this menu is a useful diagnostic test for the acquisition module–*Comlink*.

Press the F3-5 key to select the *Comlink* (communications link) test.

The communications link is a serial link test that determines if the microprocessor on the processor pcb assembly is communicating with the acquisition module.

Running the Communications Link Test

This test checks to see if the 68000 microprocessor is communicating with the acquisition module.

The communications link test is a serial link test that determines if the 68000 microprocessor is communicating with the acquisition module. Press F3-5 key, *ComLink*, to select the communications link test. The test results are shown on the lcd.

Pressing any key once stops the test. Pressing any key again restarts the test. Pressing the [⊘] key will return the acquisition module Diagnostics Menu to the lcd. Pressing the [⏎] key returns the Hardware Diagnostics Menu to the lcd.

While the test is running, flex the patient coiled cord to check it for defects.

Flex the patient coiled cord (black cord) while running this test to check the cord for defects. (For further information, see the paragraph on *No Echo* errors below.)

The signals returned by the acquisition module must match those sent by the microprocessor. If not, the acquisition module has "failed" the test.

In a properly functioning acquisition module, the number appearing after *Echo* should match the number displayed after *Cmd*.

You need to monitor only 2 parameters on the lcd to determine a pass or fail:

Cmd = Echo
No Echo = 0

While the test is running, the following messages appear on the lcd.

- *Cmd*–This is the number of the command currently being sent to the acquisition module. The following command numbers are sent continuously in this sequence until the test is stopped: 4, 5, 6, 3, 8, 9, and 10.
- *Echo*–This number shows the command number "echoed" back from the acquisition module. It should always be the same as the number displayed after *Cmd*.
- *No Echo*–A *No Echo* error occurs when the 68000 microprocessor sends a command to the acquisition module and doesn't receive a reply. A bad patient coiled cord can cause *No Echo* errors.

A *No Echo* error, occurs when the 68000 microprocessor does not receive a reply from the acquisition module.

Running the Communications Link Test (Cont)

If the acquisition module fails the communications link test, check the following.

Is the patient coiled cord fastened securely?

Try a different patient cord.

If the acquisition module fails the communications link test, first check to make sure the patient coiled cord is fastened securely to the acquisition module and to the MAC PC electrocardiograph.

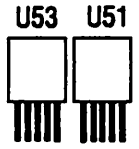
If the patient coiled cord is secure but the acquisition module continues to fail, try another patient cord.

If the communications link test still fails, replace the acquisition module with a known good one.

If with a known good patient cord and acquisition module the communications link test indicates a failing acquisition module, return the MAC PC electrocardiograph and acquisition module to the Marquette Service Division for repair.

Note, if the above steps have failed, try replacing regulator U51 on the writer assembly. This regulator controls voltage and current for the acquisition module.

Also, a typical failure in the acquisition module is crystal oscillator Y1, pn 1300-310, on the digital pcb assembly in the acquisition module.



Writer 1: Located on Front of Writer Assembly
Writer 2: Located on Top of Writer Assembly

Typical ECG Error Messages

Bad Limb Lead,
Bad Lead V4,
Bad Limb Lead LA

After pressing [12], the unit will display a message similar to those shown to the left if the quality of the ECG data is inferior to the standards of the analysis program. Poor quality in the ECG data can result from inadequate patient preparation, defective electrodes or leadwires, and/or excessive interference in the environment.

Poor quality ECG data can result from:

- poor electrode site preparation,
- defective electrodes or leadwires, and/or
- excessive 60-Hz interference from the environment.

If the operator presses [12] a second time, the unit will override the bad lead indication and print a report using substandard data. The lcd will display *Override Bad Lead* during the acquisition of data.

After pressing [12] the first time, the operator should look at the lcd for several seconds and if one of these error messages appear immediately correct the problem. That is, press the [▽] key and confirm that the aforementioned causes for poor quality ECG data are not the case.

Checking the electrode site and the electrodes...

Check the electrode site preparation and the electrode itself. Good electrode contact and placement are vital to obtaining an optimum ECG.

- Check the expiration date on the pregelled electrode. Do not use electrodes beyond their expiration date.
- Check for dry gel pads on any pregelled electrodes that have been left out of the foil package. An electrode with dried gel should not be used since good contact will not be made with the skin. Any ECG signal taken from such an electrode will be poor.
- Check to see if the gel from one electrode site has come into contact with any other electrode site. If this occurs, there may be distortion in the tracings.
- Verify that the leadwires are firmly attached.

After checking the electrodes, try running another ECG report.

After the above conditions have been met, try running another ECG report. If the error message persists, replace the suspect electrode or rub the skin at the electrode site with an alcohol pad wiping it dry with a gauze pad. Some patients, especially with a foil-type electrode, need more skin preparation.

If the error message continues to be displayed after the electrode has been replaced or reapplied, the leadwire is probably the cause of the problem.

Typical ECG Error Messages (Cont)

For each of the following error messages:

Bad Limb Lead–check all the limb electrodes/leadwires,

Bad Limb LL, *Bad Limb LA*, or *Bad Limb RA*–check the specified electrode/ leadwire, and

Bad Lead V1 (*V2*, *V3*, etc)– check the specified electrode/leadwire.

In the case of an error message *Bad Limb Lead*, press record ECG a second time and observe the 12-lead tracings.

- If there is noise everywhere, replace the RL electrode or leadwire.
- If you have a good lead I tracing, replace the LL electrode or leadwire.
- If lead II looks good, replace the LA leadwire or electrode.

In cases where the acquisition module contains a service 10-lead ECG acquisition analog pcb assembly, pn 85801-001, a bad limb electrode or leadwire will result in straight lines for all leads if the *Bad Limb Lead* message is overridden.

With some AM-1 acquisition modules, the augmented leads will straight-line if there is excessive noise on the corresponding leadwire, eg, aVR-RA, aVL-LA, and aVF-LL. For example, if you see a straightlined aVR, then the RA input is noisy.

Troubleshooting Leadwire Problems

Introduction

There are several circuit board configurations that have been used in the acquisition modules. Since each configuration handles bad leads in slightly different ways, troubleshooting a leadwire problem can be quite difficult. The following paragraphs list the circuit board configurations and the symptoms they exhibit.

AM-1 Acquisition Module Error Messages

85584-001 digital front end pcb assembly
85585-00X analog front end pcb assembly

These circuit boards were used in the original AM-1 acquisition modules.

	Symptoms	Cause
No message on lcd	Leads I, II, III, aVL, and aVF are distorted. Lead aVR is straight-lined. All V leads appear good.	Bad RA lead
BAD LIMB LEAD error message	Leads I, III, aVR, aVL, and aVF are noisy or saturated. Lead II and V leads appear good.	Bad LA lead
BAD LIMB LEAD error message	Leads I, II, III, aVR, and aVL are distorted. Lead aVF is straight-lined. V leads appear good.	Bad LL lead
BAD Vx error message	The V lead shown in the error message is straight-lined.	Bad V lead

AM-1M Acquisition Module Error Messages

85584-001 digital front end pcb assembly
85801-001 analog front end pcb assembly

These circuit boards are used in the acquisition modules upgraded to AM-1M acquisition module. This upgrade required replacement of the pn 85585-00X circuit board with the pn 85801-001 circuit board and minor modifications to the pn 85584-001 circuit board.

	Symptoms	Cause
BAD LIMB LEAD error message	All leads straight-lined.	Bad RA lead
BAD LIMB LEAD error message	All leads straight-lined.	Bad LA lead
BAD LIMB LEAD error message	All leads straight-lined.	Bad LL lead
BAD Vx error message	The V lead shown in the error message is straight-lined.	Bad V lead

Troubleshooting Leadwire Problems (Cont)

AM-2 Acquisition Module Error Messages

85692-002 digital front end pcb assembly
85691-001 analog front end pcb assembly

These circuit boards are used in the AM-2 acquisition modules.

	Symptoms	Cause
BAD RA error message	All leads straight-lined.	Bad RA lead
BAD LIMB LEAD error message	Leads I and V1–V6 are straight-lined. Leads II, III, aVR, aVL, and aVF are distorted.	Bad LA lead
BAD LIMB LEAD error message	Leads II and V1–V6 are straight-lined. Leads I, III, aVR, aVL, and aVF are distorted.	Bad LL lead
BAD Vx error message	The V lead shown in the error message is straight-lined.	Bad V lead

Straight Lines or Wrong Data on ECG Reports

Straight-lined tracings on ECG reports indicate that the data was excessively noisy when it was acquired.

If you still receive complaints of straight-lined leads, run the checkout procedures for the communications link test. As explained in preceding pages, straight-lined tracings often indicate that the input data was excessively noisy at the time it was acquired.

Suspect defective leadwire(s) and/or electrode(s), poor patient preparation, or an excessively noisy environment.

This problem is generally due to defective leadwire(s) and/or electrode(s), poor patient preparation, or an excessively noisy environment. You may have to hook up yourself to the MAC PC electrocardiograph to check out its operation completely. (Refer to the preceding pages for additional information concerning ECG error messages.)

Check the position of the leadwires on the acquisition module if the MAC PC electrocardiograph is programmed properly, but the wrong leads are appearing at the wrong time.

If the MAC PC electrocardiograph is programmed correctly but the wrong leads are appearing at the wrong time, check the position of the leadwires on the acquisition module.

Noisy ECG Data

Verify that the writer assembly is operating properly.

Complaints of noisy data are common. First run the writer diagnostic tests to verify that it is operating properly. (See chapter 7, Writer 1, or chapter 8, Writer 2.)

Excessive noise on all leads may indicate a defective RL leadwire.

Verify that the leadwires are not the source of the problem. Excessive noise on all leads may indicate a bad RL leadwire. Examine the RL leadwire and replace, if necessary.

If you have verified that the leadwires are good and the patient coiled cord is not defective and is connected securely, but excessive noise continues, then return the acquisition module to the Marquette Service Division for repair.

Excessive noise could also be due to a failure on the processor pcb assembly in the unit.

If there is excessive noise on all leads, there is a possibility that the ECG circuits on the processor pcb assembly in the MAC PC electrocardiograph are defective. Connect a known good acquisition module to the unit. If the noise continues, replace the processor pcb assembly, pn 85599-00X, or return the acquisition module and MAC PC electrocardiograph to the Marquette Service Division for repair.

If a 12-lead report looks good, consider other noise sources.

If the 12-lead report looks good, consider other sources for the noise such as poor placement of electrodes, inadequate patient preparation, or the environment.

Proper patient preparation includes...

Either hook up yourself to the unit or if possible have the operator do the preparation, so that the quality of the preparation can be observed.

You should be prone, face up on a reasonably comfortable flat surface. The flat surface should not be inclined more than 45°.

The quality of ECG data is directly related to the quality of the skin-electrode interface.

Remember the quality of the ECG data is directly related to the quality of the skin-electrode interface. Apply the limb electrodes before the chest electrodes. The limb signals are used as part of all 12 leads and allowing these electrodes more time to stabilize will result in better tracings.

The outer skin layers offer the most resistance to ECG data. Penetrating will help reduce baseline drift and other sources of noise and interference.

That is, the outer skin layers offer the most resistance to ECG data. Penetrating them will help reduce baseline drift and other sources of noise and interference. A small dc potential develops at the skin-electrode interface, much like a tiny battery. By waiting for a short time, this potential stabilizes and the MAC PC electrocardiograph can compensate for it.

Verify that the electrodes have not passed the expiration date.

Be sure that creme or gel is being used with suction-type electrodes. Confirm that disposable electrodes have not passed the expiration date and that the gel is still moist.

Noisy ECG Data (Cont)

When you are satisfied that the hookup and preparation are adequate, take an ECG. If there is still noisy data, return the acquisition module for repair.

After the above conditions have been met, try running another ECG report. If the error message persists, try replacing the suspect electrode or rub the skin at the electrode site with an alcohol pad and wipe the site dry with a gauze pad. When using a foil-type electrode, some patients need more skin preparation.

Once you are satisfied that the hookup and preparation are adequate, take an ECG. If there is still noisy data, return the acquisition module and MAC PC electrocardiograph to the Marquette Service Division for repair.

To test for environmental interference, try taking an ECG in an area away from where the problem with noisy data first occurred.

To test for environmental interference, try taking an ECG away from the area where the problem with noisy data was first noticed. If the ECG tracings are acceptable there, move the MAC PC electrocardiograph to the problem area and try again.

Remember that if the leadwires are too close to large, grounded, metal objects, conductors carrying large 60-Hz currents, or devices that generate strong magnetic or electric fields, such as power transformers, you will have problems most likely with the ECG signals. Move the MAC PC electrocardiograph away from the trouble area.

Acquisition Modules

Introduction

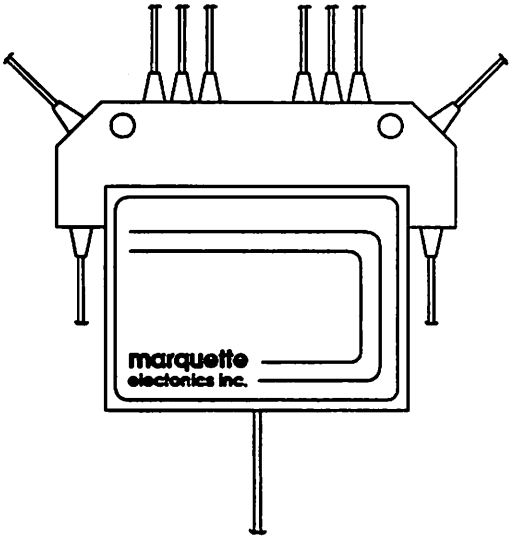
The acquisition module relays the ECG signals from the patient to the MAC PC electrocardiograph circuits.

The acquisition module serves as an interface between the patient and the MAC PC electrocardiograph. It contains amplifier and isolation stages to buffer the ECG signals received from the electrodes. It also contains analog-to-digital conversion circuits that convert the ECG data. This conversion is best performed as close to the patient as possible to minimize noise pickup in the signals as they are transmitted to the MAC PC electrocardiograph circuits. The digitized ECG data is then transmitted over a serial link to the MAC PC electrocardiograph processor pcb assembly.

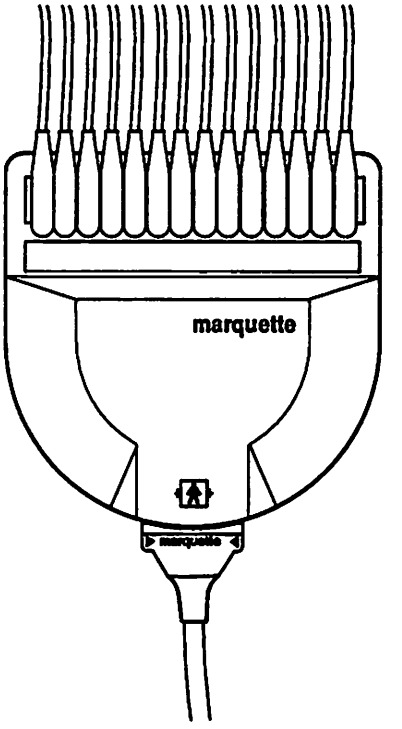
Five types of acquisition modules exist: AM-1, AM-1M, AM-2, AM-3, and AM-4.

Five types of acquisition modules exist: AM-1, AM-1M, AM-2, AM-3, and AM-4. The AM-1 acquisition module can accommodate 10 leadwires for 12-lead analysis. The AM-2 acquisition module can be used with either 10 or 14 leadwires for 12- or 16-lead analysis. All AM-2 acquisition modules are identified with the code AM-2 on a label. If there is no AM-2 code, then the acquisition module is an AM-1. The AM-1M acquisition module also has a label with the code AM-1M.

A unique label identifies the AM-3 acquisition module. The AM-4 acquisition module is recognizable by its unique design. (See figures below.)



AM-3 Acquisition Module



AM-4 Acquisition Module

Acquisition Modules (Cont)

AM-1 Acquisition Module

The AM-1 acquisition module is not a universal acquisition module.

The AM-1 acquisition module is the original acquisition module and is not as effective as later acquisition modules in handling noise interference. Also, it is not considered a "universal" acquisition module. That is, in order for the AM-1 acquisition module to be used with the MAC PC electrocardiograph with analog output (005 software), it must have the digital front end pcb assembly, pn 85584-002, with 002 firmware.

The AM-1 acquisition module contains...

The AM-1 acquisition module is typically configured with an analog front end pcb assembly, pn 85585-001 or -002 (no longer available), or a service 10-lead ECG acquisition analog pcb assembly, pn 85801-001, and a digital front end pcb assembly, pn 85584-001, -002, or -003.

Note, that the AM-1M acquisition module is not as affected by noise interference as the AM-1 acquisition module. If noise is a problem with an AM-1 acquisition module, replace it with an AM-1M acquisition module.

The analog front end pcb assembly, pn 85585-001 or -002, can be replaced with the service 10-lead ECG acquisition analog pcb assembly, pn 85801-001.

To use the replacement analog pcb assembly, the digital front end pcb assembly, pn 85584-00X, must be updated to the -003 or -004 version. Note, that the -004 version contains the -002 software. Update memo 47A has more information on modifying a pn 85584-001 to a -003.

The service 10-lead ECG acquisition analog pcb assembly, pn 85801-001, can not be used to replace the 14-lead ECG acquisition analog pcb assembly, pn 85691-001.

For additional details, refer to the paragraphs titled "Acquisition Module Product Summary" in chapter 4, General Troubleshooting.

AM-1M Acquisition Module

AM-1M acquisition module incorporates all upgrades/revisions made to the AM-1 acquisition module.

The AM-1M acquisition module is more effective than the AM-1 acquisition module at noise suppression.

The AM-1M acquisition module operates the same as an AM-2 acquisition module but without 14-leadwire capability. It can be used with MAC 12 electrocardiograph, MAC PC electrocardiograph, and CASE 12 electrocardiograph equipment.

The AM-1M acquisition module contains...

The AM-1M acquisition module is configured with the service 10-lead ECG acquisition pcb assembly, pn 85801-001, and a digital front end pcb assembly, pn 85584-004, with version 002A software.

Note, that the AM-1M acquisition module is similar to the AM-2 acquisition module but does not have 14-leadwire capability.

For additional details, refer to the paragraphs titled "Acquisition Module Product Summary" in chapter 4, General Troubleshooting.

Acquisition Modules (Cont)

AM-2 Acquisition Module

AM-2 acquisition module is a "universal" acquisition module since it can be used with all software and hardware configurations of electrocardiograph equipment.

The AM-2 acquisition module features improved noise suppression capability. It can be considered a "universal" acquisition module since it can be used with all the hardware and software configurations (including 14-leadwire capability) of MAC PC electrocardiograph, MAC 12 electrocardiograph, and CASE 12 electrocardiograph equipment.

The AM-2 acquisition module contains...

The AM-2 acquisition module is configured with a 14-lead ECG acquisition analog pcb assembly, pn 85691-001, and a 14-lead ECG acquisition digital pcb assembly, pn 85692-001 or -002.

The service 10-lead ECG acquisition analog pcb assembly can not be used in the AM-2 acquisition module.

Note, that the service 10-lead ECG acquisition analog pcb assembly, pn 85801-001, is not used in the AM-2 acquisition module as a replacement for the 14-lead ECG acquisition analog pcb assembly, pn 85691-001.

For additional details, refer to the paragraphs titled "Acquisition Module Product Summary" in chapter 4, General Troubleshooting.

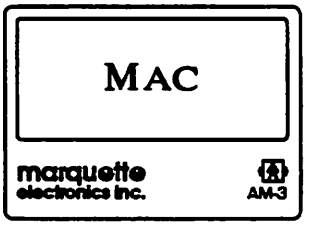
AM-3 Acquisition Module

There are several versions of the AM-3 acquisition module.

There are several versions of the AM-3 acquisition module: standard (STD), high-resolution (Hi-Res), and pacemaker (Pace) all in both AHA and IEC configurations. These standard AM-3 acquisition module acquires standard ECGs having relatively low frequency and high amplitude.

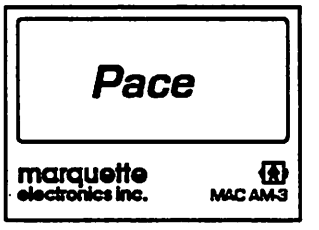
The high-resolution AM-3 acquisition modules acquire high-frequency, low-amplitude late potential signals. The pacemaker AM-3 acquisition modules acquire signals at an increased sampling rate for analyzing an implanted cardiac pacemaker.

For additional details, refer to the paragraphs titled "Acquisition Module Product Summary" in chapter 4, General Troubleshooting.



Standard AM-3
Acquisition Module Label

High-Resolution AM-3
Acquisition Module Label



Pacemaker AM-3
Acquisition Module Label

Acquisition Modules (Cont)

Acquisition Module Software

General information on AM-1 acquisition module software

There are variations in the AM-1 acquisition module software, depending on the equipment the acquisition module was shipped from the factory. More recent versions of the software operate with virtually any of the diagnostic systems. The following paragraphs briefly describe the acquisition module software history.

In the AM-1 acquisition module, EPROM U5 contains the operating software.

In the AM-1 acquisition module, EPROM U5 on the digital front end pcb assembly contains the acquisition module operating software. The following list relates the part number of the programmed EPROM and the equipment with which it was designed to operate.

Part numbers for EPROM U5 software

83349-001C is used in MAC PC electrocardiograph and MAC 12 electrocardiograph

83349-001E is used in MAC PC electrocardiograph, MAC 12 electrocardiograph, and CASE 12 electrocardiograph

83349-002A is used in MAC PC electrocardiograph, MAC 12 electrocardiograph, and CASE 12 electrocardiograph

Differences in the AM-1 acquisition module software

The C revision of the software displays a bad lead error message for 2 seconds only, then automatically overrides even if the incoming data is substandard.

The E and later revisions of the software will display a bad lead error message on the lcd until the problem is corrected or the operator presses [12] a second time to override.

The 002 software was developed so that a MAC PC electrocardiograph could have analog output when using the AM-1 acquisition module.

In the AM-2 acquisition module, software is written into U4 on the 14-lead ECG acquisition digital pcb assembly.

For the AM-2 acquisition module, software is contained in U4 on the 14-lead ECG acquisition digital pcb assembly, pn 85692-001 or -002. The AM-2 acquisition module is universal and can be used with the MAC PC electrocardiograph with analog output.

Acquisition Modules (Cont)

Lead-Fail Conditions

Messages displayed on the lcd indicating lead-fail conditions differ depending on the type of acquisition module that is used.

Recall that there is a difference between leads and electrode sites even though they may share the same name. Electrode sites are those places where electrodes are attached to the patient. They are typically identified as RA, LL, V1, V5, etc. (For additional information, refer to the paragraphs titled "Lead Formation" in chapter 4, General Troubleshooting.)

Definition of Leadwires

A leadwire connects an electrode to the circuits of the MAC PC electrocardiograph acquisition module. Leadwires are often coded with respect to the electrode sites.

Definition of Leads

Leads are combinations of 2 or more signals taken from the electrodes. They are identified as I, II, aVF, V1, V5, Z, etc.

Typical Lead-Fail Conditions

A lead-fail condition exists under several circumstances; the most important of which are excessive noise and electrode failure.

Exactly what happens under lead-fail conditions depends upon when the acquisition module was manufactured.

Generally, when a lead-fail condition is detected, an error message is displayed on the lcd. Data recorded on the writer will usually be a straight line. Exactly what happens under lead-fail conditions depends upon when the acquisition module was manufactured.

For older AM-1 acquisition modules ...

For AM-1 acquisition modules manufactured before August 1986 (serial number AXXXXXXX–G6XXXXXX), a 2-second message is displayed stating *Bad Limb Vx* or *Bad Limb Lead* whenever a leadwire becomes disconnected during the 10-second data acquisition period.

Data already acquired is eliminated and 10 seconds of new data is acquired.

Disconnected chest leadwires cause flat-line chest lead traces while disconnected limb leadwires have differing effects on the leads.

For chest leads V1 through V6, the resulting ECG waveform for a disconnected leadwire is a flat-line trace.

Disconnected limb leadwires (except RL) will have a differing effect on leads I, II, III, aVR, aVL, and aVF.

A disconnected RL leadwire will yield flat-line traces for all leads.

When RA fails, the MAC PC electrocardiograph continues to acquire data, but the resulting ECG report is distorted.

If a limb lead is disconnected prior to data acquisition, the *Bad Lead Vx* or *Bad Limb Lead* message will not appear. However, the results of such a disconnection are as stated above.

Acquisition Modules (Cont)

Lead-Fail Conditions (Cont)

For acquisition modules manufactured after August 1986...

(Serial number beginning H6... or later)

Acquisition modules (AM-1 and AM-2) manufactured since August 1986 (those with serial numbers H6XXXXXX and later) or MAC PC electrocardiographs with August 1986 or later acquisition module software will present different lead-fail conditions.

A message will appear on the lcd stating *Bad Limb Vx* or *Bad Limb Lead* (or *Bad Lead LA, Bad Lead LL*, etc) whenever a leadwire becomes disconnected prior or during the 10-second period of ECG data acquisition.

The message remains and the affected lead will yield a flat-line trace unless either the leadwire failure is corrected or [12] is pressed after at least 12 seconds of data acquisition.

If the leadwire failure is corrected...

If the leadwire failure is corrected, the bad lead message will disappear. Also, 10 seconds of data is acquired following the corrective action.

If [12] is pressed to override the detected failure...

On the other hand, if [12] is pressed after at least 12 seconds of data acquisition, an *Override Bad Lead* message will appear on the lcd. Ten seconds of data is then acquired.

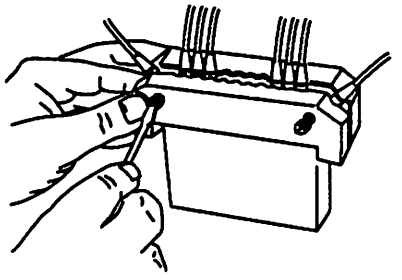
For an AM-2 acquisition module, if RL fails either before or during data acquisition, an error message may be displayed stating that a bad limb lead was detected.

Acquisition Modules (Cont)

AM-3 Acquisition Module Leadwire Replacement

Occasionally it may become necessary to replace or change one or more of the leadwires attached to the acquisition module. To do this follow the instructions below.

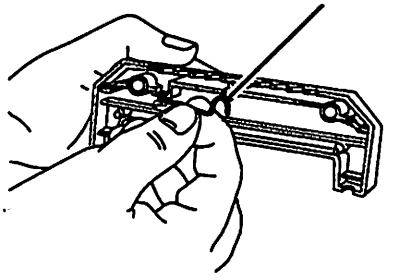
Remove the cover plate.



- Disconnect the black coiled cord from the base of the acquisition module. Use a screwdriver to loosen the 2 cover plate screws.
- After loosening the screws, remove the cover plate and gently pull out the leadwire extraction tool that is attached to the inside of the cover plate. Do not detach the extraction tool from the cover plate.

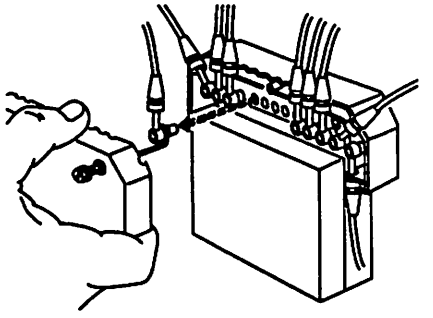
Swing out the leadwire extraction tool.

Leadwire Extraction Tool



- Use the leadwire extraction tool to remove the leadwire from its socket on the acquisition module. A new leadwire may now be placed into the empty socket. Repeat this procedure for any other leadwires that need to be replaced.
- Reassemble the acquisition module by returning the extraction tool to its original position inside the cover plate and tightening the 2 cover plate screws. Reconnect the black coiled cord to the base of the acquisition module.

Use the tool to remove the leadwire from its socket.



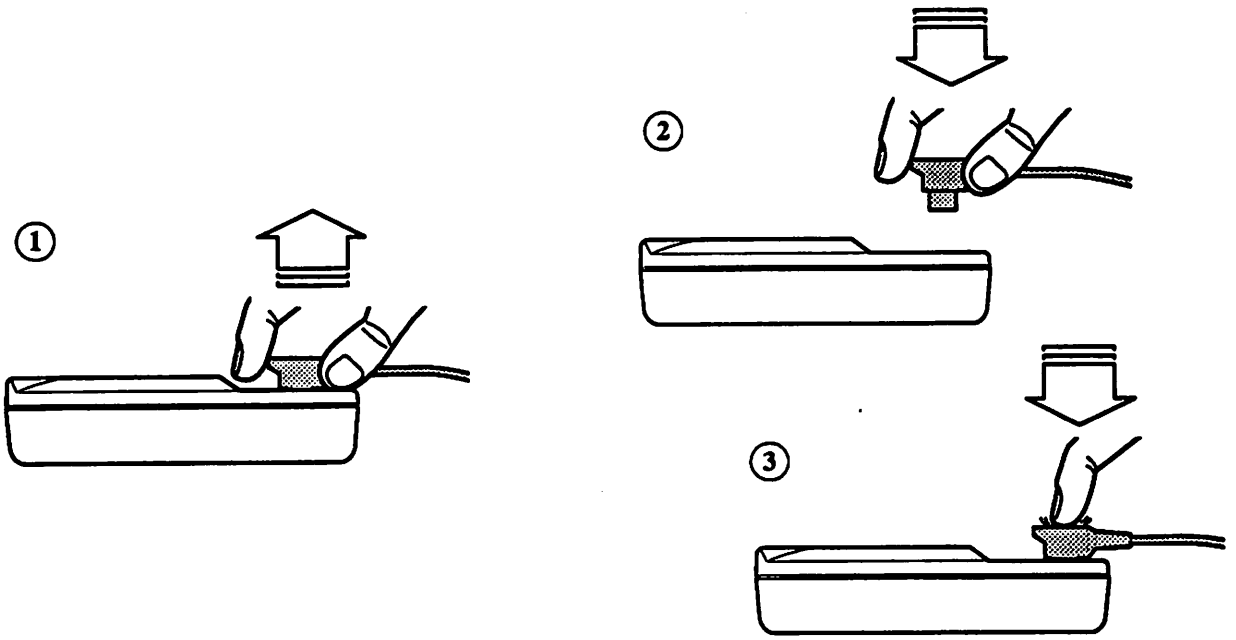
Acquisition Modules (Cont)

AM-4 Acquisition Module Leadwire Replacement

The AM-4 acquisition module is smaller in size and weighs less than earlier acquisition modules.

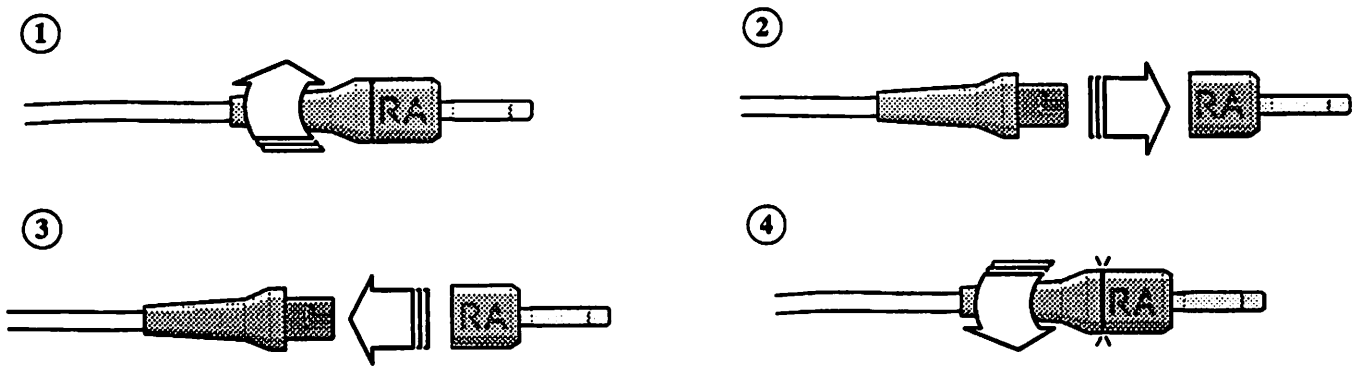
How to change leadwires

It is easy to change leadwires. (See illustrations shown below.)



How to change leadwire ends

The interlocking design provides interchangeable ends for use with disposable, snap, or suction electrodes.



Chapter 7
Writer 1

Writer 1 Troubleshooting

Introduction

This chapter identifies typical thermal writer assembly problems and describes which circuit boards or cables must be replaced, or which adjustments must be made.

This chapter checks the original version of the thermal writer assembly for electrical and mechanical problems. The revised writer (writer 2) is covered in chapter 8, Writer 2. Most of the common problems that occur with the thermal writer assembly can be identified by running the writer diagnostic tests. Note, the thermal writer assembly may be referrred to as the writer assembly or just the writer in the following text.

First, there are instructions on running the writer diagnostic tests. Specific problems that are identified by these tests are described throughout the instructions.

Once a problem is identified, either a circuit board is replaced or an adjustment is made. Adjustments are described in the paragraphs titled "Writer 1 Adjustments" in this chapter.

In the writer 1 assembly, the writer door is part the of writer assembly.

Note, the writer 1 version of the thermal writer assembly can be identified by the writer door being an integral part of the writer. The second version of the writer assembly does not have a door as such. In the Writer 2, the door is part of the MAC PC electrocardiograph case.

Writer Diagnostics

To run the Writer Diagnostics, start from the Main Menu.

Press [⇧] + [F1 2]

to reach the System Functions Menu.

Then press [F3 5] or [F3 6]

to reach the Hardware Diagnostics Menu.

Then press [F1 1] or [F1 2]

to start the writer diagnostics.

To verify operation of the thermal writer assembly, run the speed and roller tests which are part of the internal writer diagnostics.

- The speed test is used to check thermal paper speed.
- The roller test is used to check for flaws in the thermal paper roller, uneven thermal print head pressure, and burned-out thermal elements.

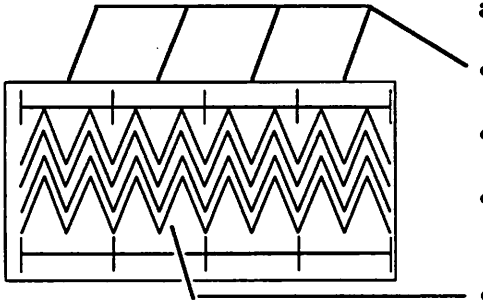
To run these tests, the Hardware Diagnostics Menu must be displayed on the lcd. Shown to the left are instructions for reaching this menu.

Once the writer tests have been started, they proceed automatically until stopped. Note, that at any time in the test you may stop it by pressing any key.

Writer 1 Troubleshooting (Cont)

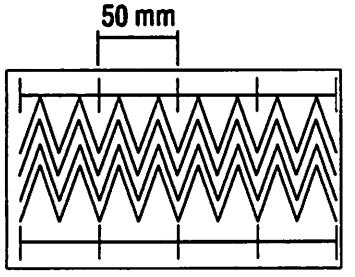
Running the Speed Test

The speed test prints a series of triangular waves across the thermal paper. The output should appear as shown to the left and as noted below.



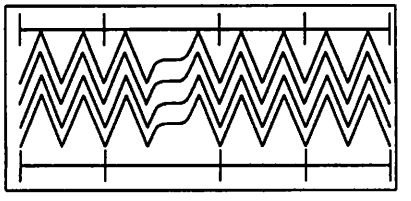
- There should be 4 areas marked off by vertical lines.
- Each area should measure 50 mm long.
- Four triangle waveforms should start at the left and be repeated 8 times before the test ends.
- The sides of the triangle waveforms should be linear.

A problem is indicated if any of the following situations occur.



- The vertical lines are not consistently 50 mm apart.

  This indicates a speed problem which could be caused by excessive thermal print head pressure. Suggested repair is to clean the thermal print head, adjust the thermal print head pressure, and if the problem persists, replace the writer assembly.

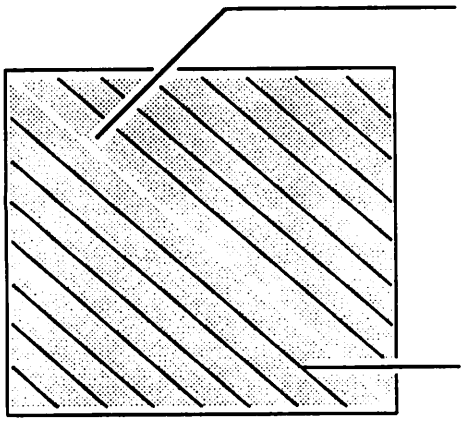


- The triangular waveforms are wavy, which could be caused by a flat spot in the capstan/roller that drives the thermal paper. Also, some other mechanical problem with the thermal paper drive could be the problem. Suggested repair is to clean the capstan/roller and if the problem persists, replace the capstan/roller.

Writer 1 Troubleshooting (Cont)

Running the Roller Test

The roller test prints a closely spaced series of vertical lines across about 5 inches of the thermal paper. These lines can be used to detect problems with the capstan/roller, incorrect thermal print head pressure, or even burned-out thermal elements. The output should appear as shown to the left and as noted below.

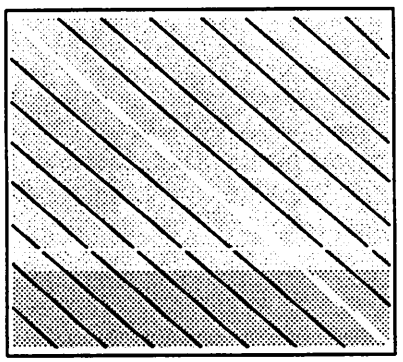


- Starting at the upper left corner of the thermal paper, a couple of the thermal print head elements are not turned on each time a vertical line is printed. For each successive line, the thermal print head elements that are left off are gradually moved down the thermal paper.

  The result is a white diagonal line down to the lower right corner of the printed area. (Note, in the sample output shown to the left, the steps in the white line are caused by the software used to generate this manual.)

- The thermal paper is advanced as printing occurs, causing a long dot to be printed. The result is a series of faint black lines parallel to the white line mentioned above. (The lines are shown much thicker than they appear on a test output.)

- The vertical lines should appear to be consistently spaced across the test area.



A problem is indicated if any of the following occur.

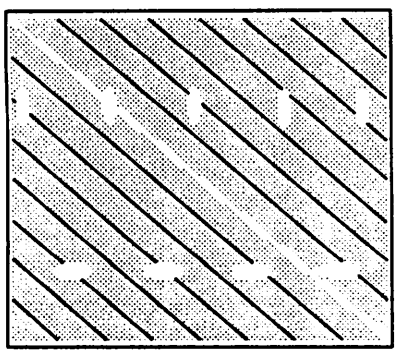
- There is a faint white horizontal line running across test area.

  This indicates a burned-out thermal element in the thermal print head. Suggested repair is to replace thermal print head.

- The vertical lines are lighter at top or bottom of the test area.

  Uneven thermal print head pressure results in the thermal paper not being held tightly against the thermal print head. Consequently, the thermal paper does not heat up completely and part of the printed area is lighter than the other.

  Suggested repair is to clean the thermal print head, check the thermal print head pressure, and if there is still a density problem, replace the thermal print head.



- A light or dark spot shows up at regular intervals in the test area.

  A flaw in the capstan/roller can cause the thermal paper to be pressed too lightly or too firmly against the thermal print head with a resulting change in the printed line's density.

  Suggested repair would be to inspect the capstan/roller, clean it if necessary, and if the problem persists, replace it.

Writer 1 Troubleshooting (Cont)

Writer Fault Error Message

Excessive current draw by the motor was detected. To solve this problem, first let the MAC PC electrocardiograph recalibrate the writer.

If the *Writer Fault* message is still displayed, suspect a mechanical problem in the writer assembly first.

If the *Writer Fault* error message is displayed during operation, the microprocessor has detected a problem with the writer. It monitors the current used by the writer and if the amount of current goes out of the acceptable range, a problem is indicated. The first step in solving the problem is to make sure the thermal print head and capstan/roller are clean of residue.

- Using a cotton swab and alcohol, clean off the print area on the thermal print head. A buildup of excessive residue can cause many problems.
- Check the capstan/roller that presses the thermal paper against the thermal print head. If it is dirty, clean it with a typewriter-style platen cleaner. Do not use alcohol to clean the capstan/roller.

Recalibrate the writer.

If cleaning the writer does not solve the problem, then try recalibrating the writer.

- Go to the Manufacturing Menu.
- Enter *Mot* to call up the Motor Test Menu.
- Select the writer option from this menu. The writer immediately starts running out the thermal paper at 25 mm/s, then 10 mm/s, and finally at 5 mm/s.
- When the writer test is done, quit it to return to the Manufacturing Menu.
- Enter *End* to exit from the Manufacturing Menu.
- Go to the Hardware Diagnostics Menu.
- Select the writer test.
- The writer should complete the tests without the *Writer Fault* message being displayed.

If after recalibrating the writer the *Writer Fault* message still is displayed, then a mechanical problem should be suspected.

Writer 1 Troubleshooting (Cont)

Writer Fault Error Message (Cont)

Check out the mechanical drive components to locate the problem.

To find the cause of the writer fault.

- Open the unit. (For details, see paragraphs titled "Opening the Unit for Service" in chapter 3, Maintenance.)
- Inspect the writer assembly, looking for obstacles that could be blocking the thermal paper going through the writer.
- Check the nylon gear, capstan gear, and motor drive gear. They should be meshed, not jammed or broken.
- The drive gear, which is next to the dc motor shaft, might be loose on the shaft. Tighten its set screw if necessary.

The *Writer Fault* error message is a sign that no tachometer pulses from the dc motor are reaching the 65C02 microprocessor. Try to rule out the following: malfunctioning tachometer, defective motor cable, missing 5V-H signal (supplies power to the logic devices in the thermal print head interface circuit), and/or faulty Q2 (motor transistor) and Q5 (thermal print head transistor).

- Close the unit. (For details, see paragraphs titled "Basic Reassembly" in chapter 3, Maintenance.)

Service may be required if the message is still shown.

If the *Writer Fault* message is still displayed, return the MAC PC electrocardiograph for service.

Writer 1 Troubleshooting (Cont)

Door Open Error Message

The *Door Open* message is the result of the motor current being low. To solve this problem, check that the door is indeed closed.

If too little current is required by the dc motor to move the thermal paper, there may not be enough pressure on the thermal paper by the thermal print head. First clean the thermal print head and capstan/roller.

- Using a cotton swab and alcohol clean off the print area on the thermal print head. Excessive residue can cause problems.
- Check the capstan/roller that presses the thermal paper against the thermal print head. If it is dirty, clean it with a typewriter-style platen cleaner. Do not use alcohol to clean the capstan/roller.

Verify that the door is closed.

- Press on the lower right corner of the door to make sure it is closed. The door should be securely latched.

  If the door is not closing securely, perform the door adjustment procedure in this chapter.

If the message is still displayed, then the thermal print head pressure may need to be adjusted.

- If the door is securely latched, but the *Door Open* message is still displayed, check the measured motor current.

  Go to the Manufacturing Menu.

  Enter *Adj* to call up the adjustment utility.

  If the measured value of the motor current is less than $40, then the thermal print head pressure must be adjusted. A procedure for this adjustment is included in this chapter.

Writer 1 Troubleshooting (Cont)

Out of Paper Error Message

If the *Out of Paper* error message occurs when there is thermal paper in the MAC PC electrocardiograph, the problem could be dirt or obstructions hindering the thermal paper movement.

If the dc motor current rises beyond the limit, an out of paper condition is suspected. If the *Out of Paper* error message is displayed, do the following.

- Double check to make sure there is thermal paper in the writer and it is threaded through the thermal print head and the capstan/roller.
- Using a cotton swab and alcohol, clean off the print area on the thermal print head. A buildup of excessive residue can cause a false *Out of Paper* error message.
- Check the capstan/roller that presses the thermal paper against the thermal print head. If it is dirty, clean it with a typewriter-style platen cleaner. Do not use alcohol to clean the capstan/roller.

Other problems can cause the *Out of Paper* error message to be displayed.

- Check that the thermal paper roll is round. If the roll was compressed, it may not rotate smoothly.
- Check that the paper is flat at the ends of the roll. If it is telescoping on one end, the thermal paper may not rotate smoothly.
- Verify that the thermal paper tension spring is not obstructing the thermal paper.

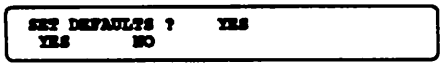
If the message is still displayed, then the thermal print head pressure may need to be adjusted.

If the *Out of Paper* message is still displayed,

- go to the Manufacturing Menu, and
- enter *Adj* to call up the adjustment utility.

If the motor current is greater than $90, then perform the procedure in the paragraphs titled "Writer 1 Adjustments" in this chapter.

If the *Out of Paper* error message continues to be displayed, reset the motor current limits.



If the *Out of Paper* message is still displayed, reset the motor current limits. The recommended way to reset the motor current limits for all thermal paper speeds is to use the *Mfg* selection under the Manufacturing Menu.

- Answer *YES* to the *Set Defaults?* question.
- Complete the remainder of the *Mfg* menu.

For details on using the *Mfg* selection, refer to the paragraphs titled "Manufacturing Menu" in chapter 2, General Information.

Writer 1 Troubleshooting (Cont)

Typical Problems with Writer 1

The following describes typical problems with the writer or door assemblies. Solutions, typically a reference to an adjustment procedure later in this chapter, are provided for each problem.

Printing density varies across the thermal paper

If the traces and/or text are light or appear faded on one side of the thermal paper, there is probably uneven thermal print head pressure. Perform the thermal print head pressure adjustment procedure. (See paragraphs titled "Writer 1 Adjustments" in this chapter.)

Printing Too Light or Dark

If the traces and/or text are consistently too light or dark across the thermal paper, there may be a problem with the thermal print head voltage. Perform the thermal print head voltage adjustment procedure. (See paragraphs titled "Writer 1 Adjustments" in this chapter.)

Horizontal white lines running through printed waveforms or text

If there are thin horizontal white lines running through the printing, one or more of the thermal elements in the thermal print head have failed. Running the roller test can positively confirm the failure.

If the burned-out elements are in an area that is not critical (the area where ECG data is plotted would be considered critical), the thermal print head does not have to be replaced. Otherwise, replace the thermal print head. (See paragraphs titled, "Writer 1 Adjustments" in this chapter.)

Uneven Printing or Ghosting

If there is uneven printing or ghosting, there may be a flat spot in the capstan/roller or it might be dirty. Clean the capstan/roller with a typewriter-style platen cleaner. Do not use alcohol.

If the problem persists after cleaning, increase the thermal print head pressure slightly. (See paragraphs titled "Writer 1 Adjustments" in this chapter.)

By increasing the thermal print head pressure on the capstan/roller, the flat spot variation in printing might be eliminated. Note, when adjusting the thermal print head pressure, you should monitor the motor current so it remains within an acceptable range.

Use *Adj* selection in Manufacturing Menu to monitor motor current.

Door does not close, closes with difficulty, or opens too easily.

Perform the door adjustment procedure described in the paragraphs titled "Writer 1 Adjustments" in this chapter.

Thermal Paper advances when the MAC PC electrocardiograph is turned off.

Experience has shown that this problem is caused by the failure of transistor Q6 on the processor pcb assembly. The MAC PC electrocardiograph should be returned to Marquette for service.

Writer 1 Troubleshooting (Cont)

Typical Problems with Writer 1 (Cont)

Thermal paper advances erratically.

If the thermal paper advances erratically or the printing is not even, there may be a problem with the thermal paper drive. Remove the cover and inspect the writer assembly. (For details, see paragraphs titled "Opening the Unit for Service" in chapter 3, Maintenance.) Check especially the nylon drive gear and capstan/roller gears; they should be meshed with no broken or jammed teeth. Also, check that the drive gear next to the dc motor is securely attached to the motor shaft. Tighten its set screw if necessary.

Writer 1 Adjustments

Introduction

This chapter contains common adjustment procedures for the original writer assembly (writer 1) and door assembly.

This chapter describes several adjustment procedures that can be performed in the field. These procedures relate only to the original writer/door assembly (writer 1). Typically one of these adjustments is performed in response to the results of one of the writer troubleshooting steps done earlier.

The chapter begins with an adjustment procedure for the door assembly. This adjustment affects the thermal paper pressure, so it is quite important.

Other than adjustments, this chapter also has a replacement procedure for the thermal print head.

The procedure for cleaning the writer 1 capstan/roller and the thermal print head can be found in the paragraphs titled "Cleaning" in chapter 3, Maintenance.

Recall, that the writer 1 version of the thermal writer assembly can be identified by the writer door being an integral part of the writer. The second version of the writer assembly does not have a door as such. In the Writer 2, the door is part of the MAC PC electrocardiograph case.

Writer 1 Adjustments (Cont)

Adjusting the Door

The door requires an adjustment if it opens too easily or is too difficult to close. Deciding when the door opens too easily is best done either by experience or by taking the cover off the MAC PC electrocardiograph. A door that is too difficult to close is much easier to discern. In either case this adjustment should be performed with care.

Note, if the door is adjusted, the writer alignment procedure (described later) may also be necessary.

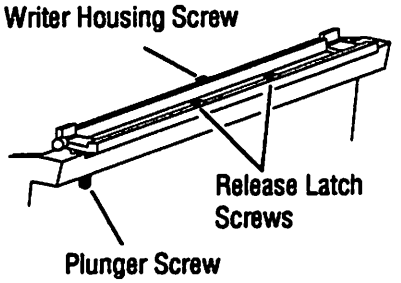
First remove the cover.

- Open the unit. (For details, see paragraphs titled "Opening the Unit for Service" in chapter 3, Maintenance.)
- Do not disconnect any of the cabling connecting the cover to the processor pcb assembly.
- Lay the cover on its top surface next to the rest of the assembly.

Press up on the door from underneath with your finger. Observe how the door opens.

To test the door, try pushing up on it from underneath with your finger. If it opens very easily, then it should be adjusted.

Adjustment Screws



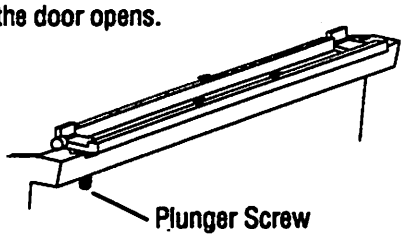
In the following procedures, these screws are used to adjust the door.

The plunger screw puts pressure on the release latch to hold the latch tight against the door.

Release latch screws control how close the release button gets to the release latch, making the latch more/less sensitive to button movement.

Writer housing screws affect sensitivity of the release latch to the release button.

If the door opens too easily, try adjusting the plunger screw, then test how easily the door opens.



First adjust the position of the plunger screw in the lower right corner of the writer. Holding the bottom of the plunger screw with a small vise-grip pliers, turn the plunger screw counterclockwise one half turn. This applies more upward pressure on the release latch to hold the door more tightly shut.

Check to see if the door is now adjusted properly. To do this, install thermal paper and then close the door. When pressed from underneath with your finger, the door should not open.

Keep adjusting the plunger screw and testing the door.

If the door is still too easy to open, try turning the plunger screw another one half turn counterclockwise. Repeat the above test for the force necessary to open the door. Keep turning the plunger screw until the required opening force is acceptable.

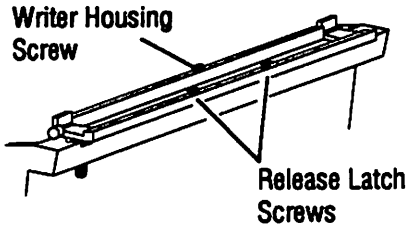
Writer 1 Adjustments (Cont)

Adjusting the Door (Cont)

Reattach the cover and test both the door and operation of the writer.

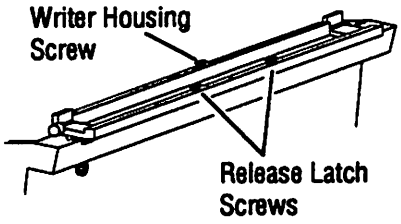
Attach the cover to the base with 3 screws. Now test the door to see how easily it opens. Verify that the paper runs properly by using the roller test. If the writer operates properly during printing, install the remaining screws that attach the cover to complete this adjustment.

There are other screws that can be adjusted if the door still opens too easily.



If the door opens too easily when the cover is attached to the base, adjust screws on the release latch and a screw on the writer housing. Turn the 2 screws on the release latch one half turn clockwise. If the 2 screws can not be turned clockwise, try turning the writer housing screw one quarter turn counterclockwise. Check the operation as described in the previous paragraph. Note that when the adjustments are done these screws should be sealed with adhesive.

If the door opens with too much difficulty, try adjusting the release latch screws.



Turn the release latch screws one half turn counterclockwise. This reduces the distance from the release latch to the release button, making the release latch more sensitive to the release button being pressed down.

Check to see if the door is now easier to open. To do this, install thermal paper in the writer, replace the cover and attach it with 3 screws, and then close the door. Try pressing on the release button and observe how much pressure it takes to open the door.

If the door still opens with too much difficulty, try adjusting the release latch screws again by another half turn. Reassemble the MAC PC electrocardiograph and test the release button again.

The writer housing screw can also be adjusted to make the release latch more sensitive to the release button.

If necessary, the writer housing screw can also be adjusted to make the release latch more sensitive to the release button. Try turning the screw by one quarter to one half turn, then reassemble the MAC PC electrocardiograph and check the door. Do not adjust the writer housing screw too much.

Note, when the adjustments are done, the writer housing screw and the release latch screws should be sealed with adhesive.

Close the unit. (For details, see paragraphs titled "Basic Reassembly" in chapter 3, Maintenance.)

Writer 1 Adjustments (Cont)

Thermal Print Head Replacement

Replacing the thermal print head is not a simple procedure.

If many thermal elements in the thermal print head are burned out or if the thermal print head has failed, it may be necessary to replace it. Replacing the thermal print head involves disassembling the MAC PC electrocardiograph and removing the writer assembly to gain access to the thermal print head. This is not a simple procedure. Use caution when performing this procedure, since the electrical assemblies are sensitive to static damage.

NOTE

Since the battery is disconnected during this procedure, all stored ECG data and setup information is lost.

Open the unit. (For details, see paragraphs titled "Opening the Unit for Service" in chapter 3, Maintenance.)

First disconnect the cables from the cover, then remove the cover.

Disconnect the battery cable from J9. Remember that the battery is always disconnected first and reconnected last.

Disconnect the display cable and keyboard cable from J4 and J3 on the processor pcb assembly.

Remove any circuit boards mounted to the processor pcb assembly.

Remove any circuit board assemblies mounted on top of the processor pcb assembly. This could be the expansion pcb assembly, modem pcb assembly, or analog/serial output pcb assembly. Note, that only one of these assemblies can be installed.

Remove hardware attaching the writer assembly to the base.

Stand the MAC PC electrocardiograph on its side. Loosen the 4 screws that secure the writer assembly to the base.

Lay the MAC PC electrocardiograph back down. Remove the 4 nuts from the screws just loosened. Set the writer assembly attaching hardware aside. Be very careful not to lose this hardware.

Disconnect cabling to the writer assembly.

Disconnect the writer assembly harness from J10 on the processor pcb assembly.

Disconnect the green grounding strap from the writer housing, next to the dc motor. On some versions of the writer assembly, the grounding strap may be located next to the door hinge.

Disconnect the motor harness from J5 on the processor pcb assembly.

Writer 1 Adjustments (Cont)

Thermal Print Head Replacement (Cont)

Lift up the writer assembly and continue disconnecting harnesses.

Note, transistor Q2 is mounted on the writer assembly, but connects to a socket on the processor pcb assembly. Use caution when lifting the writer assembly so you do not bend the leads of Q2. Carefully lift the writer assembly up about 1 or 2 inches above the processor pcb assembly.

Disconnect the thermal print head harness (yellow cable) from J2 on the processor pcb assembly.

Take the writer assembly out of the MAC PC electrocardiograph.

Lift the writer assembly out of the MAC PC electrocardiograph. Lay the writer assembly down on its back side (hinged side of the door). The thermal print head plunger screws should be pointing up.

Disconnect the remaining harnesses from the thermal print head.

Disconnect the yellow harness from the thermal print head.

Disconnect the harness from regulators U51 and U53.

Remove the thermal print head from the writer assembly.

Remove the brass-colored thermal print head support bracket.

Open the writer door and remove the thermal paper. Leave the door open.

Remove the 2 screws attaching the mounting bracket to the thermal print head.

Remove the thermal print head and discard.

Installing a new thermal print head

Inspect the new thermal print head to make sure it is not damaged.

Mark the thermal print head voltage rating on a self-adhesive label and attach it to the writer housing.

On the new thermal print head there is a voltage rating recorded by the manufacturer. Note the value and record it on a label. Attach the label to the inside of the housing. Note, once the thermal print head is installed in the writer assembly the voltage rating is not visible. Having it recorded on a label on the housing will help in any future adjustments.

Lay the thermal print head down on a soft work surface, such as a piece of cardboard or several pieces of paper. (This is done to avoid scratching or nicking the ceramic thermal print head substrate.)

Writer 1 Adjustments (Cont)

Thermal Print Head Replacement (Cont)

Attaching the mounting bracket

Attach the mounting bracket to the thermal print head using only 1 screw. Do not tightly attach the bracket. It is easier to install the thermal print head and bracket into the writer assembly if the bracket is loose.

Install the thermal print head assembly into the writer assembly. This may require some careful twisting and turning of the thermal print head assembly, since the fit is rather tight.

Insert the second mounting screw attaching the thermal print head to the mounting bracket. Do not completely tighten either of the screws.

Aligning the thermal print head

To align the thermal print head, the mounting screws should be centered in the mounting bracket slots. The washers on the mounting screws should therefore cover most of the slots in the mounting bracket.

Tighten the screws to secure the thermal print head to the mounting bracket.

Connect the harness to regulators U51 and U53.

Connect the yellow harness to the thermal print head.

Attaching the writer assembly to the base involves the following steps.

- First connect the thermal print head harness to J2 on the processor pcb assembly.
- Then carefully install Q2, which is attached to the writer assembly, into its socket on the processor pcb assembly. Make sure Q2 is properly connected, without any bent leads.
- Install the 4 mounting screws that connect the writer assembly to the base. Tighten the screws only enough to hold the writer assembly in place, it will have to be adjusted later.

Connect the motor harness to J5 on the processor pcb assembly.

Connect the ground strap to the writer assembly.

Install any optional circuit board on top of the processor pcb assembly.

Connect the keyboard and lcd harnesses to J4 or J3, respectively, on the processor pcb assembly.

Connect the battery cable to J9 on the processor pcb assembly.

Install thermal paper in the writer.

Writer 1 Adjustments (Cont)

Thermal Print Head Replacement (Cont)

The writer assembly should be attached to the base with the 4 mounting screws, but they should not be tightened.

Aligning the writer assembly

Install the cover using 3 screws (2 by the writer assembly near the top and 1 at the bottom near the keyboard).

With the MAC PC electrocardiograph positioned with the writer/keyboard facing up, open the writer door and place the writer assembly so that the door opens and closes freely.

Once a good position is found, securely hold the writer assembly in place. Lift off the cover and tighten the screws attaching the writer assembly to the base.

Verify that the door latch opens with some, but not too much, resistance.

Verifying proper thermal print head voltage

Perform the following procedures to verify the proper thermal print head voltage (or change it, if necessary).

Access the Manufacturing Menu and use the *Hed*, *Adj*, and *Mot* utilities. (For details, refer to chapter 2, "General Information".)

From the Hardware Diagnostics Menu, run the writer tests. Use the roller test to check for bad thermal elements and check for light printing.

If the writer is operating satisfactorily, install and tighten all the screws to secure the cover.

Reprogram the setup information.

Check before making any adjustments

Before you perform this thermal print head pressure adjustment procedure, run the roller test (part of the writer diagnostics under the Hardware Diagnostics Menu).

The thermal print head pressure should be adjusted if:

- an incorrect *Door Open* or *Out of Paper* error message is shown on the lcd, or
- the roller test output has faint areas of printing, has recurring light spots, or the printing overall is too light, or
- incorrect readings occur when the *Adj* selection is ran (found under the Manufacturing Menu).

Adjusting the pressure

Remove the screws securing the cover to the base, but do not remove the cover.

Writer 1 Adjustments (Cont)

Thermal Print Head Replacement (Cont)

Power up the MAC PC electrocardiograph and enter the Manufacturing Menu.

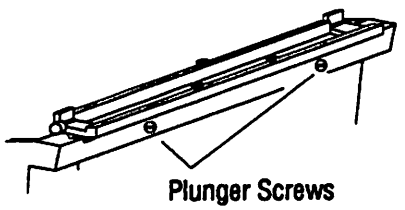
First measure the current required by the dc motor.

Run the *Adj* utility.

```
ADJUST WRITER TO CHANGE MOTOR CURRENT
MEASURED VALUE = 57 pe01 ve01 ev9D
```

Observe the two-digit value printed immediately after the equal sign. After a few moments, it should stabilize at one number.

If the value is less than $40, then the thermal print head plunger adjust screws must be turned. Turn both thermal print head plunger adjust screws one quarter turn clockwise to increase the pressure.



Plunger Screws

Check the pressure using *Adj*.

Test the pressure by running the *Adj* utility again. Adjust the plunger screws while the thermal paper is running. (To save thermal paper, press the [▽] key after reading the measured current value.)

Continue to adjust the plunger screws until the measured motor current falls in the range of $40 to $90.

Next, use the *Mot* utility to calibrate the writer.

Next, run the *Mot* utility under the Manufacturing Menu to properly calibrate the writer.

Check for even pressure across the full thermal paper width.

Verify that you have uniform pressure across the full thermal paper width, by running the roller test (part of the writer diagnostics under the Hardware Diagnostics Menu).

If the printing is light on one side of the thermal paper, try adjusting the plunger screws again. On the side where the printing is too light, adjust the plunger screw one quarter turn clockwise. On the opposite side, adjust the plunger screw one quarter turn counterclockwise to lighten the pressure on that side a small amount.

Run the roller test again, to determine if the printing is uniform. Repeat the plunger screw adjustments until the printing is even across the thermal paper.

Verify that the motor current is within the $40 to $90 range through the *Adj* utility. If not, then go back and adjust the plunger screws again.

When the motor current is within range, close the unit. (For details, see paragraphs titled "Basic Reassembly" in chapter 3, Maintenance.)

Chapter 8
Writer 2

Writer 2 Troubleshooting

Introduction

This chapter identifies typical problems for the revised thermal writer assembly (writer 2) and describes which circuit boards or cables must be replaced, or which adjustments must be made.

This chapter troubleshoots the revised version of the thermal writer assembly (writer 2) for electrical and mechanical problems. The original writer (writer 1) is covered in chapter 7, Writer 1. Most of the common problems that occur with the thermal writer assembly can be simply identified by running the writer diagnostic tests. Note, the thermal writer assembly may be referred to as the writer assembly or just the writer in the following text.

First there are instructions on running the writer diagnostic tests. Specific problems that are identified by these test are described throughout the instructions.

Once a problem is identified, either a circuit board is replaced or an adjustment is made. Adjustments are described in the paragraphs titled "Writer 2 Adjustments" in this chapter.

In the writer 2 assembly, the door is part of the MAC PC electrocardiograph case.

Note, the writer 2 version of the thermal writer assembly can be identified by the writer door being part of the MAC PC electrocardiograph case. The door does not contain any of the writer mechanism as did the original writer (writer 1) design.

Writer Diagnostics

To run the Writer Diagnostics, start from the Main Menu.

Press [⇧] + [F1 2 ↑]

to reach the System Functions Menu.

Then press [F3 5] or [F3 6 ↑]

to reach the Hardware Diagnostics Menu.

Then press [F1 1] or [F1 2 ↑]

to start the writer diagnostics.

To verify operation of the thermal writer assembly, run the speed and roller tests which are part of the internal writer diagnostics.

- The speed test is used to check thermal paper speed.
- The roller test is used to check for flaws in the thermal paper roller, uneven thermal print head pressure, and burned-out thermal elements.

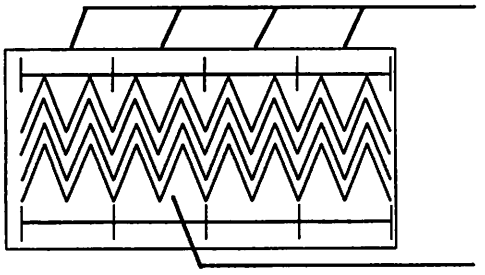
To run these tests, the Hardware Diagnostics Menu must be displayed on the lcd. Shown to the left are instructions for reaching this menu.

Once the writer tests have been started, they proceed automatically until stopped. Note, at any time during the test you may stop it by pressing any key.

Writer 2 Troubleshooting (Cont)

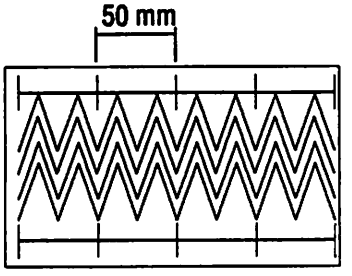
Running the Speed Test

The speed test prints a series of triangular waves across the thermal paper. The output should appear as shown to the left and as noted below.



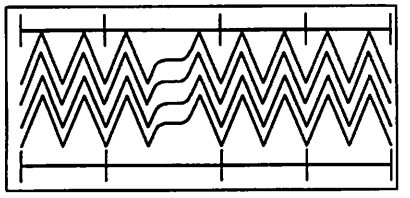
- There should be 4 areas marked off by vertical lines.
- Each area should measure 50 mm long.
- Four triangle waveforms should start at the left and be repeated 8 times before the test ends.
- The sides of the triangle waveforms should be linear.

A problem is indicated if any of the following situations occur.



- The vertical lines are not consistently 50 mm apart.

  This indicates a speed problem which could be caused by excessive thermal print head pressure. Suggested repair is to clean the thermal print head, adjust the thermal print head pressure, and if the problem persists, replace the writer assembly.

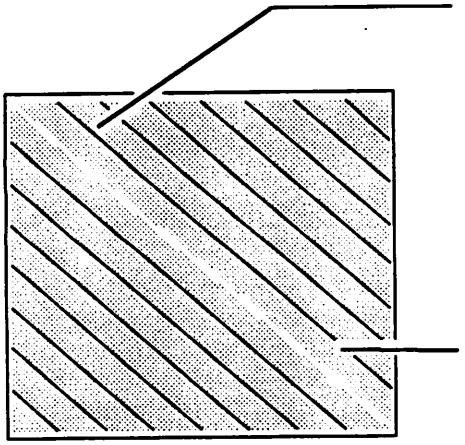


- The triangular waveforms are wavy which could be caused by a flat spot in the capstan/roller that drives the thermal paper. Also, there could be some other mechanical problem with the paper drive. Suggested repair is to clean the capstan/roller and if the problem persists, replace the capstan/roller.

Writer 2 Troubleshooting (Cont)

Running the Roller Test

The roller test prints a closely spaced series of vertical lines across about 5 inches of the thermal paper. These lines can be used to detect problems with the capstan/roller, with incorrect thermal print head pressure, or even burned-out thermal elements. The output should appear as shown to the left and as noted below.

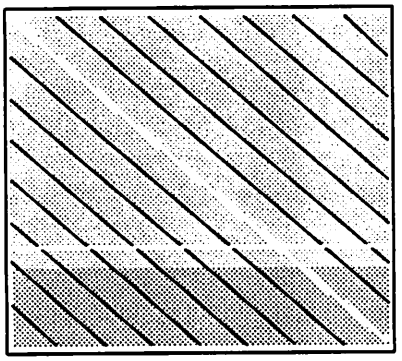


- Starting at the upper left corner of the thermal paper, a couple of the thermal print head elements are not turned on each time a vertical line is printed. For each successive line, the thermal print head elements that are left, off are gradually moved down the thermal paper.

  The result is a white diagonal line down to the lower right corner of the printed area. (Note, in the sample output shown to the left, the steps in the white line are caused by the software used to generate this manual.)

- The thermal paper is advanced as printing occurs, causing a long dot to be printed. The result is a series of faint black lines that parallel the white line mentioned above. (The lines are shown much thicker than they appear on a test output.)

- The vertical lines should appear to be consistently spaced across the test area.



A problem is indicated if any of the following occur.

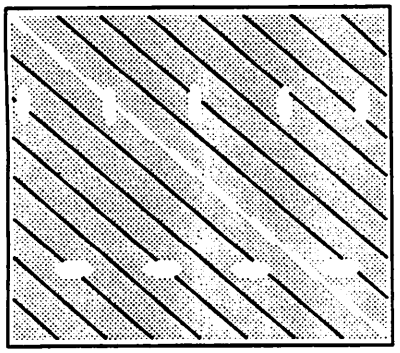
- There is a faint white horizontal line running across test area.

  This indicates a burned-out thermal element in the thermal print head. Suggested repair is to replace thermal print head.

- The vertical lines are lighter at top or bottom of the test area.

  Uneven thermal print head pressure results in the thermal paper not being held tightly against the thermal print head. Consequently, the thermal paper does not heat up completely and part of the printed area is lighter than the other.

  Suggested repair is to clean the thermal print head, check the thermal print head pressure, and if there is still a density problem replace the thermal print head.



- A light or dark spot shows up at regular intervals in the test area.

  A flaw in the capstan/roller can cause the thermal paper to be pressed too tightly or too firmly against the thermal print head with a resulting change in the printed line's density.

  Suggested repair would be to inspect the capstan/roller, clean it if necessary, and if the problem persists replace it.

Writer 2 Troubleshooting (Cont)

Writer Fault Error Message

Install thermal paper in the writer assembly.

If the *Writer Fault* error message is displayed during operation, the microprocessor has detected a problem with the writer. The first step in solving the problem is to make sure there is thermal paper in the writer assembly. Install thermal paper and run the writer for a few minutes.

If the *Writer Fault* message still is displayed, then a mechanical problem should be suspected.

If the *Writer Fault* message is still displayed, suspect a mechanical problem in the writer assembly.

To find the mechanical problems in the writer assembly, follow the steps listed below.

- Open the unit. (For details, see paragraphs titled "Opening the Unit for Service" in chapter 3, Maintenance.)
- Inspect the writer assembly, looking for obstacles that could be blocking the thermal paper going through the writer.
- Check the motor and capstan/roller gears for loose fit on their respective shafts. If any of the set screws are loose, tighten them.
- Check the drive belt tension. Tighten the belt if the tension seems unusually loose.
- Close the unit. (For details, see paragraphs titled "Basic Reassembly" in chapter 3, Maintenance.)

Service may be required if the message is still shown.

If the *Writer Fault* message is still displayed after trying to run the writer, return the MAC PC electrocardiograph to the Marquette Service Division.

Writer 2 Troubleshooting (Cont)

Door Open Error Message

The *Door Open* message is the result of the motor current being low. This problem could be caused by a dirty thermal print head or there may be some interference with the thermal paper.

If too little current is required by the dc motor to move the thermal paper, there may not be enough pressure on the thermal paper by the thermal print head. First, clean the thermal print head and capstan/roller.

- Perform the "Writer 2 Cleaning Procedure" in this chapter. If the error message still is displayed, continue with the following steps.
- Over time the thermal print head pressure spring can weaken and fail to maintain the proper tension against the thermal print head. An adjustable secondary pressure device can be installed to correct this problem. (For details, refer to "Writer 2 Adjustments" in this chapter.)
- Perform the -003 thermal print head adjustment procedure. This procedure changes the current limit value that triggers this message to be displayed. The -003 procedure can be found in the paragraphs titled "Installing a PN 1479-003 Thermal Print Head" in this chapter.

If none of the above steps solve the *Door Open* error message problem, return the MAC PC electrocardiograph to the Marquette Service Division for repair.

Writer 2 Troubleshooting (Cont)

Out of Paper Error Message

If the dc motor current rises beyond the limit, an out of paper condition is suspected.

If the *Out of Paper* error message occurs erroneously, or when trying to calibrate the writer and a message stating that the measured value is out of range occurs, try...

If the *Out of Paper* error message is displayed, try the following.

- Double check to make sure there is thermal paper in the writer and it is threaded properly through the thermal print head and the capstan/roller.
- Open the unit. (For details, see paragraphs titled "Opening the Unit for Service" in chapter 3, Maintenance.)

checking the thermal paper tension spring,

- Remove the thermal paper tension spring from the writer housing. It could be applying too much pressure on the thermal paper. This would increase the current required by the motor to move the thermal paper and hence the error message. Check if this solves the problem.

cleaning the thermal print head and capstan/roller,

- Perform the "Writer 2 Cleaning Procedure" in this chapter.

  If the error message still is displayed after cleaning the thermal print head, continue with the following steps.

checking the roll of thermal paper, or

- Check that the thermal paper roll is round. If the roll was compressed, it may not rotate smoothly.
- Check that the thermal paper is flat at the ends of the roll. If it is telescoping on one end, the thermal paper may not rotate smoothly.

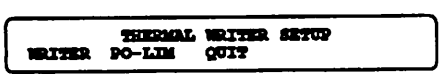
checking the tape on the thermal print head face.

- Check that the tape on the face of the thermal print head is not interfering with the thermal paper advancing. The tape should not cover more than 1/16 inch of the thermal print head. (For more information, see "Writer 2 Adjustments" in this chapter.)

If all this still has not solved the problem, try checking the current limit as specified in the "Installing a PN 1479-003 Thermal Print Head Procedure" in this chapter.

If the *Out of Paper* message is still displayed,

- go to the Manufacturing Menu, and
- enter *Mot*, select *PO-LIM*.



If the motor current is greater than 98 (represented by xx on the display shown to the left), perform the -003 thermal print head replacement procedure in the paragraphs titled "Installing a PN 1479-003 Thermal Print Head Procedure" in this chapter.

Writer 2 Troubleshooting (Cont)

Typical Problems with Writer 2

The following few pages describe typical problems with the writer 2 assembly. Solutions, typically a reference to an adjustment procedure, are provided for each problem.

Printing Too Light or Dark

If the traces and/or text are too light or dark, but consistent across the thermal paper, there may be a problem with the thermal print head voltage. Perform the thermal print head voltage adjustment procedure in the paragraphs titled "Writer 2 Adjustments" in this chapter.

Horizontal white lines running through printed waveforms or text

If there are thin horizontal white lines running through the printing, one or more of the thermal elements in the thermal print head have failed. Running the roller test can positively confirm the failure.

If the burned-out thermal elements are in an area that is not critical (the area where ECG data is plotted would be considered critical), the thermal print head does not have to be replaced. Otherwise, replace the thermal print head. (See the paragraphs titled "Writer 2 Adjustments" in this chapter.)

Uneven Printing or Ghosting

If there is uneven printing or ghosting, there may be a flat spot in the capstan/roller or it might be dirty. Clean the capstan/roller with a typewriter-style platen cleaner. Do not use alcohol.

Thermal paper advances erratically

If the thermal paper advances erratically or the printing is not even, there may be a problem with the thermal paper drive. Remove the cover and inspect the writer assembly. (For details, see paragraphs titled "Basic Reassembly" in chapter 3, Maintenance.)

Check especially the nylon drive gear and capstan/roller gears. They should be meshed with no broken or jammed teeth. Also check that the drive gear next to the dc motor is securely attached to the motor shaft. Tighten its set screw, if necessary.

Writer 2 Adjustments

Thermal Print Head Replacement

If many thermal elements in the thermal print head are burned out or if the thermal print head has failed, it may be necessary to replace. Replacing the thermal print head involves disassembling the MAC PC electrocardiograph and removing the writer assembly to gain access to the thermal print head. This is not a simple procedure. Use caution when performing this procedure, since the electrical assemblies are sensitive to static damage.

The writer 2 version of the thermal writer assembly can be identified by the writer door being part of the MAC PC electrocardiograph case. The door does not contain any of the writer mechanism as did the original writer (writer 1) design.

Before replacing the thermal print head, check the following items.

Verify that there is a strip of tape covering the junction of the aluminum face plate and the thermal print head. This piece of tape is intended to prevent the thermal paper from snagging or catching on the edge of the aluminum face plate.

Note, however, the tape should not cover more than 1/16 inch of the thermal print head. If it does, then it could be interfering with the thermal paper, causing excessive thermal print head pressure that might make the MAC PC electrocardiograph inoperable.

Verify that there is a strip of white protective material covering the top edge of the thermal print head. This material prevents the copper-colored anti-static fingers from electrically shorting to the thermal print head.

For 004 software, if a pn 1479-003 thermal print head is installed, another adjustment procedure must be used.

Note, if the MAC PC electrocardiograph has the 004 or earlier version of software and the -003 thermal print head, you may have to perform the adjustment procedure for the -003 thermal print head once it has been replaced.

The software version is shown during the powerup displays or on a report (ie, Pgm 004). The -003 thermal print head can be distinguished by the lack of external wiring connected to the face edge of the thermal print head. There are no wiring or solder connections to the edge of the thermal print head face.

Removing the Thermal Print Head

The replacement procedure is dived into removing the thermal print head and then installing a new one.

Open the unit. (For details, see the paragraphs titled "Opening the Unit for Service" in chapter 3, Maintenance.)

Writer 2 Adjustments (Cont)

Thermal Print Head Replacement (Cont)

First disconnect the cables from the cover, then set the cover off to the side of the work area.

Disconnect the battery cable from J9 on the processor pcb assembly. Remember that the battery is always disconnected first and reconnected last.

Disconnect the display cable and keyboard cable from J4 and J3 on the processor pcb assembly.

Set the cover off to the side.

Remove any circuit boards mounted to the processor pcb assembly.

Remove any circuit board assembly that is mounted on top of the processor pcb assembly. This could be an expansion pcb assembly, a modem pcb assembly, or an analog/serial output pcb assembly. Note, only one of these assemblies can be installed at a time.

Remove thermal paper from the writer.

Remove hardware attaching the writer assembly to the base.

Stand the MAC PC electrocardiograph on its side. Loosen the 4 screws that secure the writer assembly to the base.

Lay the MAC PC electrocardiograph back down. Remove the 4 nuts from the screws just loosened. Set the writer assembly attaching hardware aside. Be very careful not to lose this hardware.

Disconnect cabling to the writer assembly.

Disconnect the writer assembly harness from J10 on the processor pcb assembly.

Disconnect the motor harness from J5 on the processor pcb assembly.

Lift up the writer assembly and continue disconnecting harnesses.

Note, transistor Q2 is mounted on the writer assembly, but connects to a socket on the processor pcb assembly.

Use caution when lifting the writer assembly so you do not bend the leads of Q2. Carefully lift the writer assembly up about 1 or 2 inches above the processor pcb assembly.

Disconnect the thermal print head harness (yellow cable) from J2 on the processor pcb assembly.

Disconnect the regulator harness, at the end opposite the motor, from J12 on the processor pcb assembly.

Disconnect the green ground strap from J11 on the processor pcb assembly.

Take the writer assembly out of the MAC PC electrocardiograph.

Lift the writer assembly out of the MAC PC electrocardiograph.

Lay the writer assembly down on its back side (yellow thermal print head harnesses pointing up).

Writer 2 Adjustments (Cont)

Thermal Print Head Replacement (Cont)

Disconnect the remaining harnesses from the thermal print head.

Disconnect the yellow thermal print head harnesses from the thermal print head.

Remove the thermal print head from the writer assembly.

Remove the 3 screws from the thermal print head pressure spring assembly. Set the spring assembly and brace aside.

Using a small flat screwdriver, remove the snapring from the pivot rod at the motor end of the rod.

Remove the pivot rod from the writer assembly (pull to the right away from the motor).

Be extremely careful not to bend or damage the copper-colored anti-static fingers!

Gently slide the thermal print head down and away from the writer assembly. Be very careful not to bend or otherwise damage the copper-colored anti-static fingers.

Remove the ground strap connected to the thermal print head.

Remove the last screw attaching the thermal print head to the pivot plate assembly.

Remove the thermal print head from the pivot plate assembly and discard the thermal print head.

Note, the copper-colored anti-static fingers are easily bent when removing and installing the thermal print head. Bent fingers can damage the new thermal print head, so be very careful!

Installing a new thermal print head

Inspect the new thermal print head to make sure it is not damaged.

Mark the thermal print head voltage rating on a self-adhesive label and attach it to the inside of the writer housing.

On the new thermal print head, there is a voltage rating recorded by the manufacturer. Record this value on a label. Attach the label to the inside of the housing.

Note, once the thermal print head is installed in the writer assembly the voltage rating is not visible. Having it recorded on a label inside the housing will help in future voltage adjustments.

Attach the thermal print head to the pivot plate and install the assembly into the writer housing.

Attach the pivot plate to the thermal print head. (Note, if you are using a pn 1479-KIT to replace the thermal print head, do not install a screw in the center mounting hole on the pivot plate.)

Connect the ground strap to the left mounting screw for the thermal print head.

Carefully install the thermal print head assembly into the writer assembly. Do not bend the copper-colored anti-static fingers!

Install the pivot rod into the writer housing and the pivot plate.

Install the small snapring onto the pivot rod.

Install the thermal print head pressure spring assembly.

Writer 2 Adjustments (Cont)

Thermal Print Head Replacement (Cont)

Start to reconnect cabling to the writer assembly.

Connect the yellow thermal print head harness to the processor pcb assembly.

Holding the writer assembly about one half inch above the processor pcb assembly, connect the thermal print head harness (yellow cable) to J2 on the processor pcb assembly. Connect the harness to transistor Q2 on the writer assembly.

Connect regulator harness to J12 on the processor pcb assembly.

Attach the writer assembly to the base. Install the 4 mounting screws that connect the writer assembly to the base.

Connect the motor harness to J5 on the processor pcb assembly.

Connect the ground strap to J11 on the processor pcb assembly.

Install the circuit board on top of the processor pcb assembly.

Connect the keyboard and lcd cables, J4 and J3 respectively, onto the processor pcb assembly.

Connect the battery cable to J9 on the processor pcb assembly.

Close the unit. (For details, see the paragraphs titled "Basic Reassembly" in chapter 3, Maintenance.)

Install thermal paper in the writer assembly.

After installation, the replacement thermal print head voltage must be entered in the *Hed* utility.

Perform the following procedures to verify the proper thermal print head voltage.

- Access the Manufacturing Menu, by pressing the F1-1 and F5-0 keys as the power switch is momentarily pressed, and use the *Hed* utility.

Set the thermal print head voltage if necessary.

- Verify that the thermal print head voltage setting matches the value for the new thermal print head. If not, enter new value.

Verify the motor current.

Use the *Adj* utility to measure the motor current. To save thermal paper, press the [▽] key after reading the measured current value. For the thermal print head, pn 1479-003, the current reading should be in the range $40 to $90. If the displayed value is outside this range, try the "Thermal Print Head Pressure Adjustment" which begins on the following page.

Calibrate the writer.

Use the *Mot* utility in the Manufacturing Menu to calibrate the writer. Allow calibration to run through all 3 thermal paper speeds.

Run the writer tests.

From the Hardware Diagnostics Menu run the writer tests. Use the roller test to check for bad thermal elements and light printing.

Reprogram the MAC PC electrocardiograph.

If the writer is operating satisfactorily, reprogram the MAC PC electrocardiograph with the setup information you wrote down or printed out before starting the disassembly.

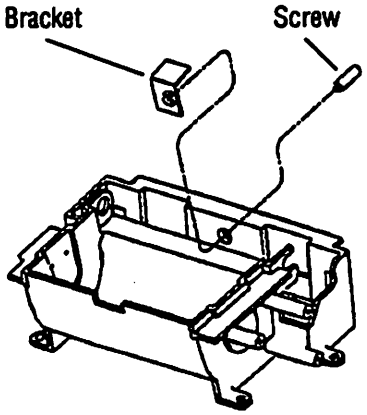
Writer 2 Adjustments (Cont)

Thermal Print Head Pressure Adjustment

The need to adjust thermal print head pressure is indicated if:

- an incorrect *Door Open* or *Out of Range* error message is shown on the lcd during calibration, or
- the thermal writer output has faint areas of printing, has recurring light spots, or if the printing overall is too light, or
- incorrect readings occur when the *Adj* selection is run under the Manufacturing Menu.

Over time the thermal print head pressure spring can weaken and fail to maintain the proper tension against the thermal print head. An adjustable secondary pressure device (bracket and screw) can be installed to correct this.



To install the new plunger screw (pn 405763-001) and bracket (pn 403722-001), follow the steps listed below.

- Open the unit to gain access to the writer. (For details, see paragraphs titled "Opening the Unit for Service" in chapter 3, Maintenance.)
- Place the bracket between thermal print head and the thermal writer casting. (See illustration shown to left.)
- Insert the plunger screw through the hole in the thermal writer casting and thread into bracket.
- Adjust screw to obtain proper thermal print head pressure.

Check the pressure using *Adj*.

Test the pressure by running the *Adj* utility. Adjust plunger screw while the thermal paper is running. (If you want to save thermal paper, press [▽] key after reading the measured current value.)

Turn the plunger screw until the measured motor current falls in the range of $40 to $90.

Next, use the *Mot* utility to calibrate the writer.

Next, run the *Mot* utility under the Manufacturing Menu to properly calibrate the writer.

Check for even pressure across the full width of thermal paper.

Verify that you have uniform pressure across the full thermal paper width, by running the roller test (part of the writer diagnostics under the Hardware Diagnostics Menu).

If the printing is light on one side of the thermal paper, try adjusting the plunger screw again. Run the roller test again, to determine if the printing is uniform. Repeat the plunger screw adjustments until the printing is even across the thermal paper.

Verify motor current is within $40 to $90 range through the *Adj* utility. If not, then go back and adjust the plunger screw again.

When the motor current is within range, close the unit. (For details, see the paragraphs titled "Basic Reassembly" in chapter 3, Maintenance.)

Writer 2 Cleaning Procedure

Introduction

To clean the writer 2 assembly thermal print head, some disassembly is required.

Due to the design of the writer 2 assembly, cleaning the thermal print head involves some disassembly of the MAC PC electrocardiograph. This makes the cleaning process more involved and therefore close attention to the following procedure is necessary.

A thorough cleaning involves both the capstan/roller and the thermal print head. The capstan/roller can be cleaned while still installed in the writer assembly, if that is all that requires cleaning.

To clean the thermal print head, however, the capstan/roller must be removed from the writer assembly to get to the printing area.

Note, all stored information will be lost when this cleaning procedure is performed.

The first step in the cleaning procedure opens the unit. (See "Opening the Unit for Service" in chapter 3, Maintenance.)

Capstan/Roller Cleaning

This procedure is meant for cleaning the capstan/roller without removing it from the writer assembly.

If only the capstan/roller requires cleaning, the MAC PC electrocardiograph need not be disassembled. Note, if the capstan/roller is dirty, there could be uneven printing, light or dark spots in the printing, or even malfunctions in the thermal paper drive due to improper thermal print head pressure.

To clean the capstan/roller while still in the MAC PC electrocardiograph, follow the steps below.

- Open and remove the thermal paper door from the MAC PC electrocardiograph.
- Remove the thermal paper from the writer assembly.
- Using a typewriter platen cleaner, wipe off the capstan/roller. Advance the capstan/roller by pressing the left facing arrow on the lower left of the keyboard.

Do not use alcohol to clean the capstan/roller!

Do not use alcohol or alcohol solutions to clean the capstan/roller, since the alcohol dries the rubber compound used in the capstan/roller. The result is warping and cracking of the rubber. Let the capstan/roller dry completely.

- Install thermal paper in the writer.
- Install and close the thermal paper door.

Writer 2 Cleaning Procedure (Cont)

Thermal Print Head Cleaning

The design of the writer 2 assembly allows the capstan/roller to be removed. This provides easy access to the printing area on the thermal print head. It is then a relatively simple step to clean the printing area.

All stored ECG data and setup information is lost as a result of this cleaning procedure!

The first part of this procedure involves disassembling the MAC PC electrocardiograph and writer 2 assembly. (See paragraphs titled "Thermal Print Head Replacement" in this chapter.)

Removing the capstan/roller

First, the capstan/roller must be removed from the writer assembly as follows.

- Open the unit. (For details, see paragraphs titled "Opening the Unit for Service" in chapter 3, Maintenance.)
- Disconnect battery cable from J9 on processor pcb assembly.

  Disconnect the keyboard and display cables, J4 and J3, respectively, from the processor pcb assembly.
- Remove thermal paper from the writer assembly.
- Carefully remove the timing belt from the capstan/roller gear. This is easier if the belt is held with 2 fingers near the gear.

  Slowly pull the belt off the gear, towards the motor. You may need to rotate the gear to move the belt.

Be extremely careful not to damage the copper-colored anti-static fingers.

- Carefully pull back on tge thermal print head, away from the capstan/roller.

  Be extremely careful pulling back on the thermal print head not to bend the copper-colored anti-static fingers that extend over its top.

  Pull the thermal print head as far towards the writer housing as possible.
- Note, the writer housing is slotted at the motor end for the capstan/roller. You must pull the capstan/roller towards the thermal print head until it is out of the slot. When pulling the capstan/roller, try to pull only on the gear at the motor end.
- Once the capstan/roller is pulled out of the slot, you must slide it towards the motor to remove its bearing on the other end from the writer housing. Since the bearing fits rather tightly, this is not easy. Moving the capstan/roller back and forth slightly while pulling helps release the bearing.
- Pull the capstan/roller out of the writer housing. Allow the thermal print head to return to its original position.

Clean the thermal print head

- Apply alcohol to a cotton swab or sterile gauze pad. Carefully wipe clean the thermal print head face. Be very careful not to bend the copper-colored anti-static fingers at the top of the thermal print head.

Writer 2 Cleaning Procedure (Cont)

Thermal Print Head Cleaning (Cont)

Cleaning the capstan/roller

Do not use alcohol to clean the capstan/roller!

- Using a typewriter platen cleaner, wipe off the capstan/roller.

  Do not use alcohol or alcohol solutions to clean the capstan/roller since the alcohol dries the rubber compound used in the capstan/roller. The result is warping and cracking of the rubber.

  Let the capstan/roller dry completely.

Install the capstan/roller back into the writer.

- Pull back on the thermal print head as far as it will go and insert the capstan/roller into the writer housing. Be very careful not to bend the copper-colored anti-static fingers near the top of the thermal print head.

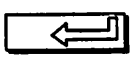
  Make sure capstan/roller seats in hole in the writer housing.

- Slide the capstan/roller into the slot in the end of the writer housing by the motor. Make sure the capstan/roller is seated completely in the writer housing.
- Install the timing belt on the motor and capstan/roller gears. You may need to rotate the gears slightly to move the belt onto them. The timing belt should be centered on the gears.
- Connect the keyboard and display cables to, J4 and J3, respectively, on the processor pcb assembly.

Reassemble the MAC PC electrocardiograph.

- Connect battery cable to J9 on the processor pcb assembly.
- Close the unit. (For details, see paragraphs titled "Basic Reassembly" in chapter 3, Maintenance.)
- Put thermal paper back into the writer assembly.
- Power up the MAC PC electrocardiograph.

Calibrate the writer.

- Enter the Manufacturing Menu by pressing the F1-1 and F5-0 keys and momentarily pressing the power switch. Enter the password "MACPC" to get to the Manufacturing Menu.
- Enter *Mot* to get to the thermal writer Setup Menu.
- Select the Writer test by pressing F1-1 key, then press the  key to start. Allow writer to calibrate at all speeds.
- When the thermal writer Setup Menu is again displayed, select *QUIT* by pressing the F3-5 key.
- When the display returns to the Manufacturing Menu, enter *End*. The Main Menu should then be displayed.

Reprogram the MAC PC electrocardiograph.

- Enter the Setup Menu and reprogram the unit with the user's preferences (which you wrote down or printed out before starting the disassembly).

Installing a PN 1479-003 Thermal Print Head

Special circumstances require extra steps when the replacement thermal print head is pn 1479-003, and the software is version 004B or earlier.

The following procedure describes special circumstances that occur when an existing thermal print head is replaced with a pn 1479-003 thermal print head and the operating software is version 004B or earlier. Note, this procedure is only relevant if these conditions apply to the MAC PC electrocardiograph being repaired.

The pn 1479-003 thermal print head can be identified by the lack of external wiring connected to the edge of the thermal print head face. Also, note there are no solder connections to the edge of the thermal print head face. You will not find the part number, 1479-003, marked anywhere on the thermal print head.

The current limit for the paper out condition must be changed since the drag exerted by the new thermal print head is higher.

The problem that is corrected by this procedure involves a change in the current limit value programmed into the MAC PC electrocardiograph for the out of paper condition. If this value is not increased, the MAC PC electrocardiograph will report paper out conditions when there really is thermal paper in the writer. The -003 thermal print head does not have the same amount of drag exerted on the thermal paper, so more current is required by the motor to drive the thermal paper past the thermal print head.

Enter the Manufacturing Menu, select the *Mot* utility, then select the *PO-LIM* option. The display will show the programmed *Out of Paper* current limit value.

To determine if the out of paper current value must be changed, use one of the utilities of the Manufacturing Menu. To access the Manufacturing Menu press down the F1-1 and F5-0 keys, then briefly press the power switch. A password request is displayed on the lcd. After entering "MACPC" and pressing the ⇦ key, the Manufacturing Menu is displayed. Enter *Mot*, and then select the *PO-LIM* option. The display then shows the programmed *Out of Paper* current limit value.

```
      25MM PAPEROUT BUFFER
RANGE 32 >    < 105 CURRENT [  xx ]
```

The paper out current limit value is displayed as shown to the left. If the value (xx) is 98, then the following procedure is not necessary, and it SHOULD NOT be performed. If the value (xx) is 82, then the following procedure MUST be performed.

- If the value inside the brackets is 82, enter 98 on the numeric keypad. Note, the entered value appears between the arrows in the display.
- Once the correct value has been entered, press the return key several times until the Manufacturing Menu is again displayed.

```
HEX LOCATION ? ____    DATA = __
```

- Now enter *Sho* to display the memory contents utility. The display will appear as shown to the left.

```
HEX LOCATION ? 0048    DATA = 3F
      3F 62 32 32 32 32 32 A0
```

- Enter the value 0048. The display changes to show the memory contents.

Installing a PN 1479-003 Thermal Print Head (Cont)

- Press both the right and left arrow keys at the same time, then release them after a moment.
- Press [⇦] key.

- Add 30 to the value shown after the equal sign (in the left example, 3F). Enter the new value (in the example, the sum would be 6F). It will appear, after a short pause, after the equal sign and in the first position in the second line of the display.
- Press the [⇦] key again, then press the stop key to return to the Manufacturing Menu.
- Enter *Mot* to select the utility, then select the writer option. Allow the writer speed to calibrate at all 3 speeds.
- When the *Mot* utility is again displayed, enter *QUIT*.
- To exit the Manufacturing Menu, enter *End*.

Chapter 9
Modem

Modem

Introduction

The modem pcb assembly can be checked out after all other functions of the MAC PC electrocardiograph have been tested and are functioning properly.

The modem pcb assembly accepts digital ECG data from the processor pcb assembly. It converts the data into an audio-frequency signal which is transmitted over standard telephone lines to a MUSE system. The MUSE system reviews and stores the data.

With the addition of a straight cable (pn 5516-005), the MAC PC electrocardiograph can be configured to send to and receive from another MAC PC electrocardiograph locally. This is done by connecting a straight cable from the acquisition module connector on the receiving unit to the auxiliary connector on the transmitting unit.

Instead of using the internal diagnostic tests, try transmitting data to verify that the modem pcb assembly is working properly.

This chapter describes very briefly how to troubleshoot problems with the modem pcb assembly. The MAC PC electrocardiograph contains several internal modem diagnostic tests. However, you can check out its functioning most easily by using the modem pcb assembly to transmit data.

If a problem is isolated to the modem pcb assembly, replace it.

Therefore, most of these troubleshooting steps rely on error messages shown on the lcd. In general, if a problem is isolated to the modem pcb assembly, the recommended repair is to replace it.

Transmitting Data

Set up the MAC PC electrocardiograph to transmit ECG data.

To prepare for the following troubleshooting steps, set up the MAC PC electrocardiograph to transmit data over a telephone line. Connect a telephone cord from a telephone wall connector to the telephone connector on the back panel of the MAC PC electrocardiograph. (Only a unit equipped with a modem pcb assembly can receive ECG reports by telephone.)

```
        System Functions
Storage  Setup  Diag  RevXmit Monitor
```

```
        Storage Functions
Plot  Dirctry Summary  Delete  More
```

```
        Storage Functions
Transmit  Edit  Format         More
```

```
        Transmission type
Phone   Local   RS232
```

If the Main Menu is not already displayed, press the stop key. Next, press the shift key and F1-2 to display the System Functions Menu. Next, press one of the two keys as shown in the displays to the left.

```
   ** No Data in Storage **
```

Pressing function key F1-1 or F1-2 produces one of two displays. The first display, shown to the left, indicates that you will need to acquire and store ECG data. Press 12-lead key to acquire data.

```
Phone Number:
0-9 # * = ,
```

If the second display appears, type in the telephone number of the location where you will be transmitting and press the enter key.

```
123456789  ALLEN, BRADLEY
 Yes    No    No...  Yes...  Expand
```

Next, patient data on each stored ECG will be displayed as shown to the left. Press the first *Yes*.

```
    ** Batch Transmission **
Waiting for Dial Tone
```

```
    ** Batch Transmission **
Dialing 1112345
```

```
    ** Batch Transmission **
Waiting for an Answer Tone
```

```
    ** Batch Transmission **
123456789   JONES, JACK
```

If the unit is operating properly, the following sequence of messages will be displayed for each ECG that is transmitted.

```
  5  of    5 Transmitted
Type Any Key to Continue
```

```
        Transmission type
Phone   Local   RS232
```

After all ECGs have been transmitted, 2 additional messages will appear. A message indicating the number of ECGs that were transmitted vs the number you selected to transmit will be displayed as shown to the left. Pressing any key displays the final message. Press the stop key to return to the Main Menu.

If there is a problem during transmission, an error message is displayed which often implies what to do to solve the problem.

This is the typical sequence for transmission. If there is a problem, an error message is displayed which often indicates where to start in solving the problem.

No Dial Tone Error Message

No Dial Tone is displayed on the lcd.

If at the start of data transmission, the error message shown to the left is displayed, try the following troubleshooting steps.

Is the telephone cord connected?

- Verify that the telephone cord is connected to the MAC PC electrocardiograph telephone connector and to the wall connector.

Is the telephone cord good?

- Check if the telephone cord is good. Try the cord on another telephone and make a telephone call to verify that signals are getting through.

Is the telephone cable inside the MAC PC electrocardiograph connected?

- Confirm that the cable from the telephone connector on the MAC PC electrocardiograph is connected internally to J2 on the modem pcb assembly.

If all else fails, replace the modem pcb assembly.

- If none of the above steps solves the problem and the error message still occurs, replace the modem pcb assembly.

No Answer Tone Error Message

No Answer Tone is displayed on the lcd.

If the MAC PC electrocardiograph does not receive an answer tone after dialing, the error message shown to the left is displayed. Try these troubleshooting steps.

Is the correct telephone number programmed into the unit?

Are you calling the correct telephone number?

- Verify that the correct telephone number is programmed in the MAC PC electrocardiograph. (See the operator's manual. For details, see "Related Manuals" in chapter 1, Introduction.)
- To determine if you are calling the correct telephone number, use a regular telephone and call the number. When the system answers, you should hear a high-pitched (2025-Hz) answer tone.

  This is followed several seconds later by intermittent beeping at a lower frequency. The beeping tones indicate that the system is polling the caller. The interval between polls is approximately 1 second. The duration of each poll is also about 1 second.

  If you do not hear the answer tone and polling tones, then you probably have a wrong telephone number programmed in the unit. (See the operator's manual. For details, see "Related Manuals" in chapter 1, Introduction.)

No Modem Error Message

No Modem is displayed on the lcd.

The base of transistor Q1 and the metal standoff below it may be shorted.

If *No Modem* is displayed on the lcd or there is only intermittent operation of the modem function, there may be a short between the base of transistor Q1 on the modem pcb assembly and the metal standoff below it.

Check for continuity between the metal standoff and the base of transistor Q1. If the standoff is shorted, remove the modem pcb assembly from the unit. Desolder and reposition the lead of Q1's base away from the metal standoff. Resolder the lead.

Future versions of the modem pcb assembly will be etched differently to avoid this problem.

ECG Not Stored/Transmitted! Retry? Error Message

The transmission is not completed.

If an error message appears on the lcd indicating that the ECG data was not stored or transmitted, try the following troubleshooting steps.

Is the site number correct?

Confirm that the site number is correctly programmed in the unit. The *Misc* (miscellaneous) option under the Setup Menu can be used to program the correct site identification number. (See the operator's manual. For details, see "Related Manuals" in chapter 1, Introduction.)

Is the patient identification number correct?

Verify that the number of patient identification digits (PIDs) matches the requirements of the MUSE system (if you are transmitting to a MUSE system). A standard MUSE system requires 9 patient ID digits. Note, if the unit is Swedish, the patient identification digits will be 10 instead of 9.

A CAPOC system (used by the military) requires 11 patient identification digits. The *Misc* (miscellaneous) option under the Setup Menu can be used to program the correct number of patient identification digits. (See the operator's manual. For details, see "Related Manuals" in chapter 1, Introduction.)

Unit Appears Not to Have a Modem

If the MAC PC electrocardiograph has a modem pcb assembly installed but operates as if there is no modem...

Suspect a problem with the MAC PC electrocardiograph recognizing the modem pcb assembly if

- while starting to transmit data, the transmission is not completed and the Main Menu is displayed prematurely, or
- the lcd displays a message which indicates that any function that requires a modem is not available.

Check the cable from the telephone connector on the MAC PC electrocardiograph to J2 on the modem pcb assembly.

Confirm that the cable from the telephone connector on the MAC PC electrocardiograph is connected internally to J2 on the modem pcb assembly.

If the problem persists, replace the modem pcb assembly.

If the problem persists, replace the modem pcb assembly.

Problems in Reverse Transmission Mode

The MAC PC electrocardiograph answers but then terminates the call.

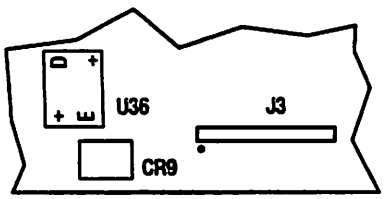
The reverse transmission function on the MAC PC electrocardiograph has been activated to receive from a MUSE system. The MAC PC electrocardiograph answers, but then terminates the call.

Check the modem setup values (part of Cart Setup menu) and change if they do not match the following.

Transmit Sync Time: 148.3 ms
Answer Tone Frequency: 2025 Hz

MAC PC electrocardiograph will not answer telephone.

If the MAC PC electrocardiograph will not answer the telephone in reverse transmission mode, U36 may have been installed incorrectly on the modem pcb assembly.



Modem PCB Assembly

The "E" and "+" connections should be towards CR9. The "D" and "+" should be towards the inside of the pcb assembly. If U36, pn 3152-001, is installed backwards, replace it.

(Note, the problem only occurs on modem pcb assemblies that were installed as part of an upgrade kit or service spare. Production MAC PC electrocardiographs are tested in the reverse transmission mode before leaving the factory.)

Chapter 10
Parts Lists and Drawings

This chapter covers the OMAR drawings for the MAC PC electrocardiograph which began March, 1988. The MAC PC electrocardiograph drawings that occurred before this time can be found in the MAC PC Parts Reference Manual, pn 407099-001. Note, all of the MAC PC electrocardiograph drawings can be found in the parts reference manual. Also, the "Commonly Replaced Parts" list found in this chapter provides many of the more commonly used pre-OMAR part numbers.

Chapter 10
Parts Lists and Drawings (Cont)

Introduction

This chapter contains upper level drawings and parts lists for the standard configurations of the unit.

This chapter contains upper level drawings and parts lists for the standard configurations of the unit. These parts lists and exploded views show the unit as it was designed at a specific point in time. The baseline for this chapter is March, 1988. (The assembly drawings covering the unit before this date can be found in the parts reference manual.) Changes made to the design are shown on assembly revision pages.

The unit you received may reflect some of these changes. Therefore, if you need to order a part for the unit be sure to check the assembly revisions pages for the latest part numbers.

The MAC PC Parts Reference Manual contains parts lists and part location and schematic diagrams for the pcb assemblies.

The MAC PC Parts Reference Manual, pn 407099-001, contains all of the parts lists and drawings for the unit including the pcb assemblies. A list of related manuals includes all the relevant documentation (both operator and service) for the unit. (For details, see chapter 1, Introduction.)

A "Commonly Replaced Parts" list precedes the regular parts lists and drawings. This parts list provides some of the most frequently used part numbers.

"How to Reach Us" gives details on ordering parts.

For details on ordering service parts and supply products refer to the page titled "How to Reach Us" located in the front of the manual.

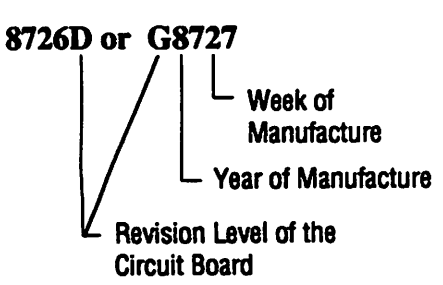
The following information is required to order parts:

- Marquette part number.

If this part number can not be readily found, then you should have the following information:

- equipment model and serial number,
- part number and name of the assembly in which the part is used (listed in the parts lists/exploded views in the service manual),
- part name, and
- part reference designation (eg, R45, S1, U23).

Printed circuit board identification



Printed circuit boards are typically identified with a part number silkscreened somewhere on the component side of the board. On the processor pcb assembly, the part number is located at the upper right corner of the printed circuit board and should be 85599-00X where the X represents 1, 2, 3, etc.

It is important to supply the entire part number when ordering a replacement board. Also, on the component side of the printed circuit board there should be a self-adhesive label with a code written on it. The code consists of revision level of the printed circuit board and when the printed circuit board was manufactured. Typical codes are shown to the left.

Commonly Replaced Parts

Part Number	Part Description
3807-001	Battery
5516-001	Coiled patient cord, 3-foot
5516-005	Straight cable (for *Local* option)
6132-005	Power supply assembly, PM-3
9488-21X	Patient acquisition module
9518-001	Power module, 120 V (MAC PM, cabling not included)
9518-206	MAC PC power module-2 (MAC PM, with cabling)
9577-001	Power module, 120 V (MAC PM-3, with cabling)
88853-001	Power supply (Power One)
80562-003	Harness (Power One)
88853-004	Power supply (Condor)
58163-001	Shock boot
58164-001	Studs (2 required)
80274-101	AC power supply cable assembly (for PM-3)
80629-001	AC power supply cable assembly (for PM and PM-2)
80630-001	DC power supply cable assembly (for PM and PM-2)
80746-001	DC power supply cable assembly (for PM-3)
85599-001	Processor pcb assembly
85599-002	Processor pcb assembly
85599-003	Processor pcb assembly
85599-004	Processor pcb assembly
85626-001	Power supply pcb assembly, 120 V (for PM)
85626-101	MAC PC-2 power module pcb assembly
85637-001	Modem pcb assembly
85676-001	EPROM expansion pcb assembly
85843-001	Analog/serial output pcb assembly
88694-001	Keyboard assembly, alphanumeric
88694-101	Keyboard assembly (includes lcd)
88714-002	LCD assembly

Commonly Replaced Parts (Cont)

Part Number	Part Description
Writer 1	
45117-218	Plunger screw for thermal print head (2 necessary)
57601-001	Capstan assembly
57602-002	Thermal paper roll bar
88661-100	Writer door assembly
88710-002	Thermal writer assembly, 4-inch
88718-001	Motor assembly—w/tachometer
Writer 2	
1479-003	Thermal print head
1479-KIT	Thermal print head replacement kit for writer 2
1479-003	Thermal print head
400533-003	Static brush
58457-003	Pivot plate
4500-404	Screw (2)
57602-002	Thermal paper roll bar
58489-001	Capstan assembly
88718-001	Motor assembly—w/tachometer
88860-001	Thermal writer assembly, 4-inch Secondary pressure device
405763-001	Plunger screw
403722-001	Bracket
Parts needed for grounding modifications:	
88714-002	LCD assembly
403945-002	Current-limiting pcb assembly
Miscellaneous items	
9402-023	Recording paper
9612-001	Skin preparation analyzer
9266-001	ECG simulator

Commonly Replaced Parts (Cont)

MAC PC Software Part Numbers

The part numbers for the latest released software are listed below an on the following page. For additional information, see paragraphs titled "Software/Hardware Configurations" in chapter 4, General Troubleshooting.

MAC PC (1M EPROMs)

English Version 108A
Upgrade Kit PN 900254-008
Firmware PN 300027-008
EPROM PN 83350-007B
PN 83351-108A
PN 83352-108A

French Version 108A
Upgrade Kit PN 900254-003
Firmware PN 300046-007
EPROM PN 83506-007B
PN 83507-108A
PN 83508-108A

Italian Version 108A
Upgrade Kit PN 900254-006
Firmware PN 300058-007
EPROM PN 83568-007B
PN 83569-108A
PN 83570-108A

German Version 108A
Upgrade Kit PN 900254-002
Firmware PN 300052-007
EPROM PN 83499-007B
PN 83500-108A
PN 83501-108A

Spanish Version 108A
Upgrade Kit PN 900254-004
Firmware PN 300057-007
EPROM PN 83563-007B
PN 83564-108A
PN 83565-108A

Swedish Version 108A
Upgrade Kit PN 900254-005
Firmware PN 300076-007
EPROM PN 83509-107B
PN 83510-108A
PN 83511-108A

Serbo Version 105CA
Upgrade Kit PN 900017-005
Firmware PN 400781-002
EPROM PN 83819-006BA
PN 83820-105CA
PN 83821-105CA

CAPOC Version 106A
Upgrade Kit PN 900017-009
Firmware PN 300065-002
EPROM PN 83350-006B
PN 83591-106A
PN 83592-106A

Commonly Replaced Parts (Cont)

MAC PC Software Part Numbers (Cont)

MAC PC (512K EPROMs)

English Version 008A

Upgrade Kit	PN – Not available
Firmware	PN 300027-007
EPROM	PN 83350-007B
	PN 83351-008A
	PN 83352-008A
	PN 83464-008A
	PN 83465-008A

French Version 008AA

Upgrade Kit	PN – Not available
Firmware	PN 300046-006
EPROM	PN 83506-007B
	PN 83507-008A
	PN 83508-008A
	PN 83561-008A
	PN 83562-008A

Italian Version 008AA

Upgrade Kit	PN – Not available
Firmware	PN 300058-006
EPROM	PN 83568-007B
	PN 83569-008A
	PN 83570-008A
	PN 83571-008A
	PN 83572-008A

German Version 008AA

Upgrade Kit	PN – Not available
Firmware	PN 300052-006
EPROM	PN 83499-007B
	PN 83500-008A
	PN 83501-008A
	PN 83561-008A
	PN 83562-008A

Spanish Version 008AA

Upgrade Kit	PN – Not available
Firmware	PN 300057-006
EPROM	PN 83563-007B
	PN 83564-008A
	PN 83565-008A
	PN 83566-008A
	PN 83567-008A

Swedish Version 008AA

Upgrade Kit	PN – Not available
Firmware	PN 300076-006
EPROM	PN 83509-007B
	PN 83510-008A
	PN 83511-008A
	PN 83645-008A
	PN 83646-008A

Serbo Version 005CA

Upgrade Kit	PN – Not available
Firmware	PN 400781-001
EPROM	PN 83819-006BA
	PN 83820-005CA
	PN 83821-005CA
	PN 83822-003BA
	PN 83823-003BA

CAPOC Version 006A

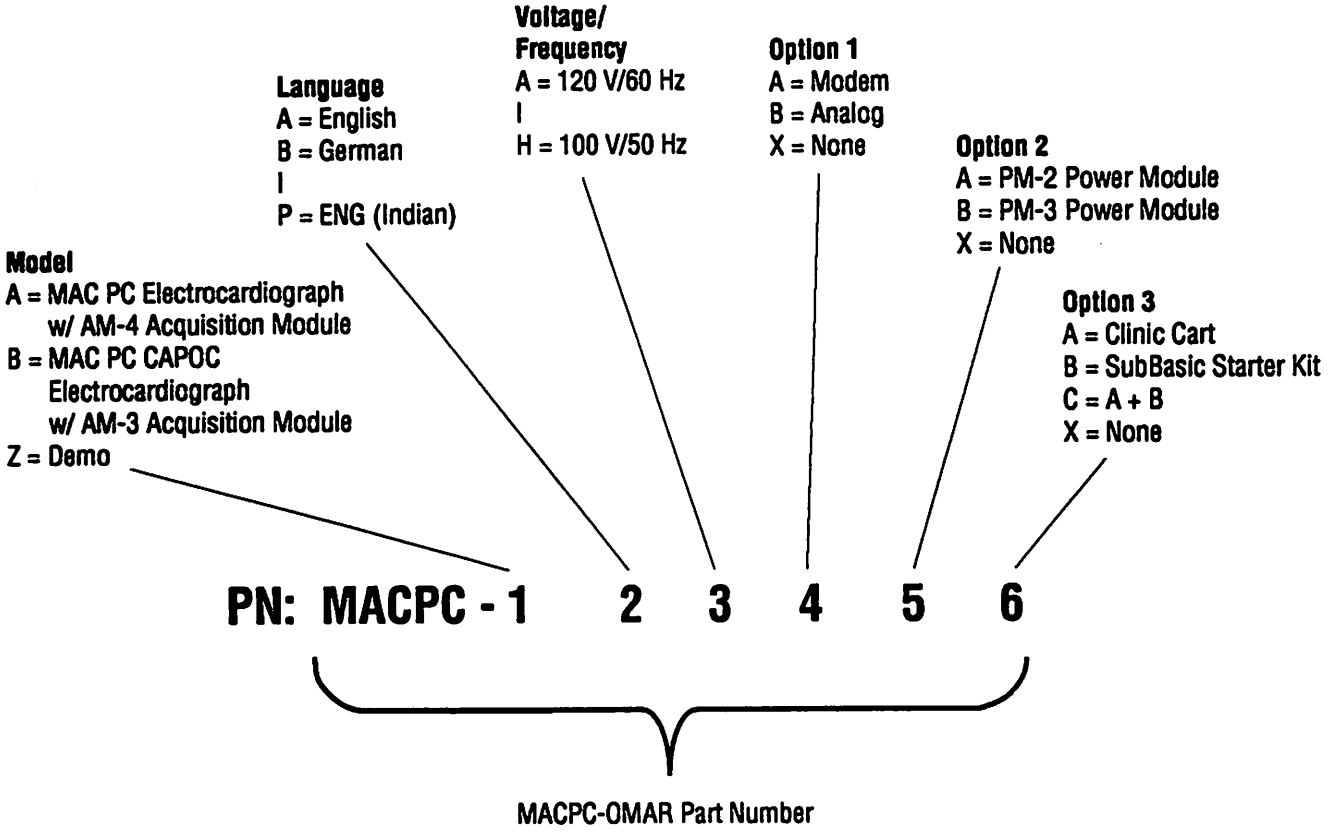
Upgrade Kit	PN 9478-929
Firmware	PN 300065-003
EPROM	PN 83350-006B
	PN 83591-006A
	PN 83592-006A
	PN 83594-004A
	PN 83595-004A

MACPC-OMAR

OMAR Part Number and Product Descriptor

The OMAR (Order Management Accounts Receivable) part number and product descriptor are constructed to reflect the possible choices in configuring any given upper-level assembly, in this case the MAC PC electrocardiograph. MAC PC electrocardiograph options include: modem, analog output, foreign languages, and cart. All MAC PC electrocardiographs ship with an AM-4 acquisition module. CAPOC MAC PC electrocardiographs ship with an AM-3 acquisition module.

The OMAR part number contains 6 positions for describing the configuration. An example of a MACPC-OMAR part number is shown below.



Examples of Typical Configurations

PN: MACPC-AAAXXX
MAC PC electrocardiograph with AM-4 acquisition module, English language documentation, 120 V/60 Hz

PN: MACPC-BAAXXA
MAC PC CAPOC electrocardiograph with AM-3 acquisition module, English language documentation, 120 V/60 Hz with clinic cart.

The most recent revision of the MACPC-OMAR list begins on the next page.

MACPC-OMAR

PART NUMBER: MACPC-OMAR
DESCRIPTION: MAC PC OMAR STRUCTURE
DATE: 9-24-91
REVISION: G
VALIDATED BY: GREG MCELWAIN

SHEET 1 OF 3

MACPC - (1) (2) (3) (4) (5) (6)

MODEL (1)

A	MAC PC W/AM-4
B	MAC PC CAPOC W/AM-3 STD
Z	DEMO

OPTION 1 (4)

A	MODEM
B	ANALOG
X	NONE

LANGUAGE/POWER CORD (2)

A	ENGLISH	I	ENG(GB)
B	GERMAN	K	ENG(AHA)
C	FRENCH	L	ENG(IEC)
D	SPANISH	M	ENG(SWISS)
E	SWEDISH	N	ENG(DANISH)
F	ITALIAN	O	ENG(ISRAELI)
H	ENG(AUST)	P	ENG(INDIAN)

OPTION 2 (5)

A	PM-2
B	PM-3
X	NONE

VOLTAGE/FREQUENCY (3)

A	120V 60HZ
B	120V 50HZ
C	220V 60HZ
D	220V 50HZ
E	240V 60HZ
F	240V 50HZ
G	100V 60HZ
H	100V 50HZ

OPTION 3 (6)

A	CLINIC CART
B	SUB BASIC STARTER KIT
C	[A + B]
X	NONE

MACPC-OMAR

DATE: 2-OCT-1991 SHEET 2 OF 3
PART NUMBER: MACPC-OMAR
DESCRIPTION: MAC PC OMAR STRUCTURE
DRAWING:
REVISION: G

QTY	ITEM	PART NUMBER	DESCRIPTION
1.00	1	401855-010	PWR CORD AUSTRALN 10A 250V 8FT
1.00	2	401855-009	PWR CORD DANISH 10A 250V 8FT
1.00	3	401855-008	PWR CORD INDIAN 10A 250V 8FT
1.00	4	401855-007	PWR CORD SWISS 10A 250V 8FT
1.00	5	401855-004	PWR CORD ISRAELI 10A 250V 8FT
1.00	6	401855-003	PWR CORD ITALIAN 10A 250V 8FT
1.00	7	401855-002	PWR CORD BRITISH 10A 250V 8FT
1.00	8	401855-001	PWR CRD CONT EURO 10A 250V 8FT
1.00	9	405535-006	CORD POWER RA 125V 15A 10FT
1.00	10	9518-206	MAC PC PM-2 120V UL
1.00	11	9518-205	MAC PC PM-2 240V IEC
1.00	12	9518-204	MAC PC PM-2 220V IEC
1.00	13	9518-203	MAC PC PM-2 200V IEC
1.00	14	9518-202	MAC PC PM-2 120V IEC
1.00	15	9518-201	MAC PC PM-2 100V IEC
1.00	16	9577-004	MAC PC PM-3 100V
1.00	17	9577-003	MAC PC PM-3 240V
1.00	18	9577-002	MAC PC PM-3 220V
1.00	19	9577-001	MAC PC PM-3 120V
1.00	20	9478-903	ASSY MOBILE CART MAC PC
1.00	21	90056-125	MAC PC SERBO W/ANALOG 220V
1.00	22	90056-001	MAC PC ENGLISH 120V
1.00	23	90056-002	MAC PC ENGLISH W/MODEM 120V
1.00	24	90056-003	MAC PC ENGLISH W/ANALOG 120V
1.00	25	90056-015	MAC PC ENGLISH 220V
1.00	26	90056-016	MAC PC ENGLISH W/MODEM 220V
1.00	27	90056-017	MAC PC ENGLISH W/ANALOG 220V
1.00	28	90056-006	MAC PC ENGLISH 240V
1.00	29	90056-007	MAC PC ENGLISH W/MODEM 240V
1.00	30	90056-008	MAC PC ENGLISH W/ANALOG 240V
1.00	31	90056-009	MAC PC ENGLISH 100V
1.00	32	90056-010	MAC PC ENGLISH W/MODEM 100V
1.00	33	90056-011	MAC PC ENGLISH W/ANALOG 100V
1.00	34	90056-012	MAC PC ENGLISH 200V
1.00	35	90056-013	MAC PC ENGLISH W/MODEM 200V
1.00	36	90056-014	MAC PC ENGLISH W/ANALOG 200V
1.00	37	90056-004	MAC PC CAPOC 120V
1.00	38	90056-005	MAC PC CAPOC W/MODEM 120V
1.00	39	90056-018	MAC PC CAPOC 220V
1.00	40	90056-019	MAC PC CAPOC W/MODEM 220V
1.00	41	90056-100	MAC PC GERMAN 220V
1.00	42	90056-110	MAC PC GERMAN W/MODEM 220V
1.00	43	90056-120	MAC PC GERMAN W/ANALOG 220V
1.00	44	90056-106	MAC PC FRENCH 120V
1.00	45	90056-116	MAC PC FRENCH W/MODEM 120V
1.00	46	90056-126	MAC PC FRENCH W/ANALOG 120V
1.00	47	90056-101	MAC PC FRENCH 220V
1.00	48	90056-111	MAC PC FRENCH W/MODEM 220V
1.00	49	90056-121	MAC PC FRENCH W/ANALOG 220V
1.00	50	90056-107	MAC PC SPANISH 120V

MACPC-OMAR

DATE: 2-OCT-1991 SHEET 3 OF 3
PART NUMBER: MACPC-OMAR
DESCRIPTION: MAC PC OMAR STRUCTURE
DRAWING:
REVISION: G

QTY	ITEM	PART NUMBER	DESCRIPTION
1.00	51	90056-117	MAC PC SPANISH W/MODEM 120V
1.00	52	90056-127	MAC PC SPANISH W/ANALOG 120V
1.00	53	90056-102	MAC PC SPANISH 220V
1.00	54	90056-112	MAC PC SPANISH W/MODEM 220V
1.00	55	90056-122	MAC PC SPANISH W/ANALOG 220V
1.00	56	90056-104	MAC PC SWEDISH 220V
1.00	57	90056-114	MAC PC SWEDISH W/MODEM 220V
1.00	58	90056-124	MAC PC SWEDISH W/ANALOG 220V
1.00	59	90056-103	MAC PC ITALIAN 220V
1.00	60	90056-113	MAC PC ITALIAN W/MODEM 220V
1.00	61	90056-123	MAC PC ITALIAN W/ANALOG 220V
1.00	62	5510-001	CORD POWER 18-3 SVT IEC 7.5FT
1.00	63	900156-001	KIT STARTER MAC PC BASIC
1.00	64	900156-101	KIT STARTER MAC PC AHA DELUXE
1.00	65	900156-102	KIT STARTER MAC PC IEC DELUXE
1.00	66	9488-701	AM-3 RESTING STD AHA
1.00	67	9488-702	AM-3 RESTING STD IEC
1.00	68	90056-108	MAC PC FRENCH/CANADA
1.00	69	90056-118	MAC PC FRENCH/CANADA W/MODEM
1.00	70	90056-128	MAC PC FRENCH/CANADA ANALOG
1.00	71	900183-001	AM-4 REST 10-LEAD AHA MAC6/PC
1.00	72	900183-002	AM-4 REST 10-LEAD IEC MAC6/PC

How to Use Assembly Revisions Pages

Changes made to the original design are shown on assembly revision pages.

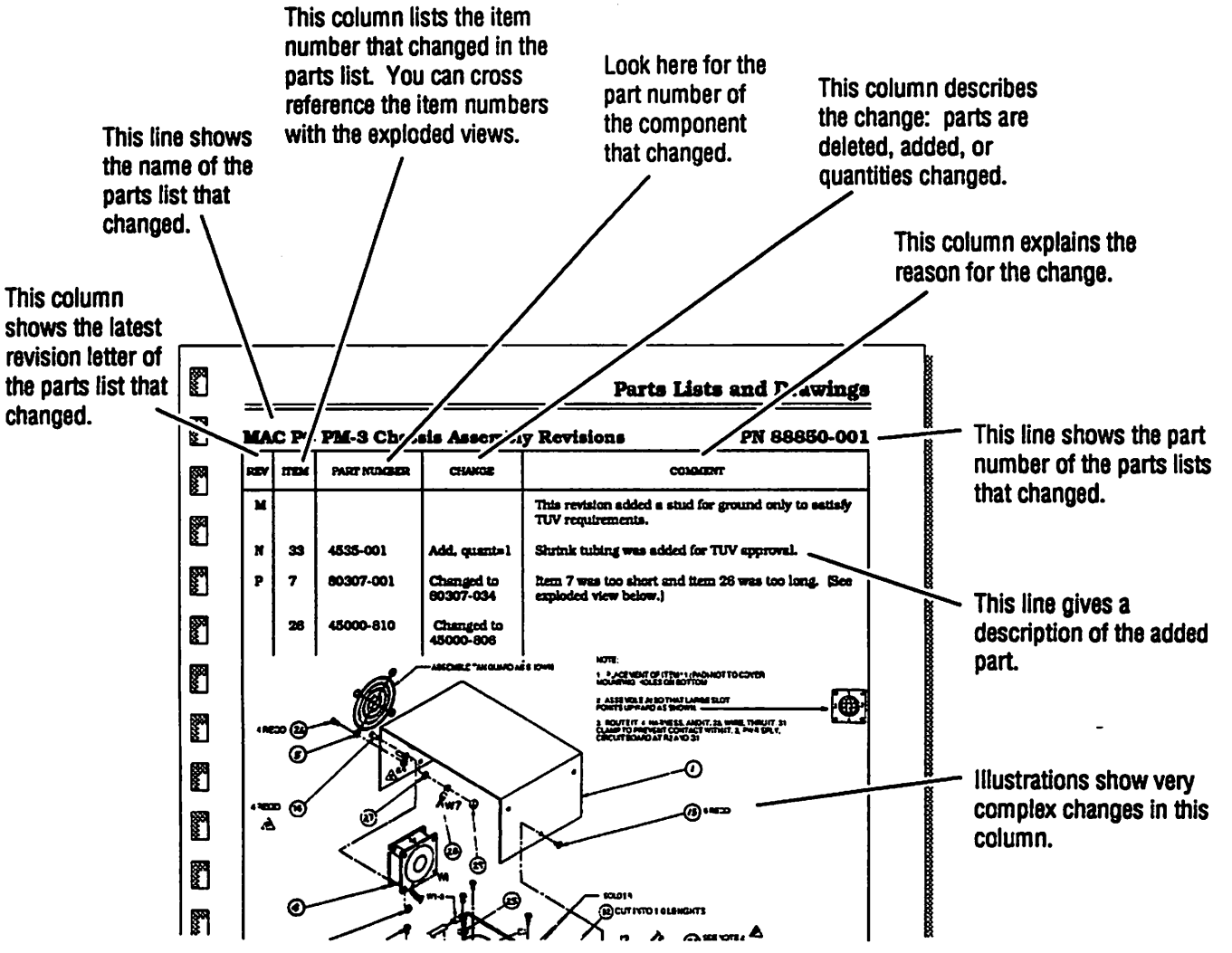
This chapter provides parts lists and exploded views for field-serviceable assemblies in the MAC PC electrocardiograph. These parts lists and exploded views show the unit as it was originally designed for shipment to customers. Changes made to the original design are shown on assembly revision pages. Over time, if the accumulated changes come to represent a significantly different unit, a new parts lists and exploded view are added.

The unit you received may reflect some of these changes.

Therefore, if you need to order a part for the unit be sure to check the assembly revisions pages for the latest part numbers.

If you need to order a part, be sure to check the assembly revisions pages for the latest part numbers.

On assembly revision pages, a table format summarizes the changes made to any of the parts lists. You read the table from left to right. See the illustration of a typical revisions page (below) for more information.



REV	ITEM	PART NUMBER	CHANGE	COMMENT
M				This revision added a stud for ground only to satisfy TUV requirements.
N	33	4535-001	Add, quant=1	Shrink tubing was added for TUV approval.
P	7	80307-001	Changed to 80307-034	Item 7 was too short and item 26 was too long. (See exploded view below.)
	26	45000-810	Changed to 45000-806	

NOTES

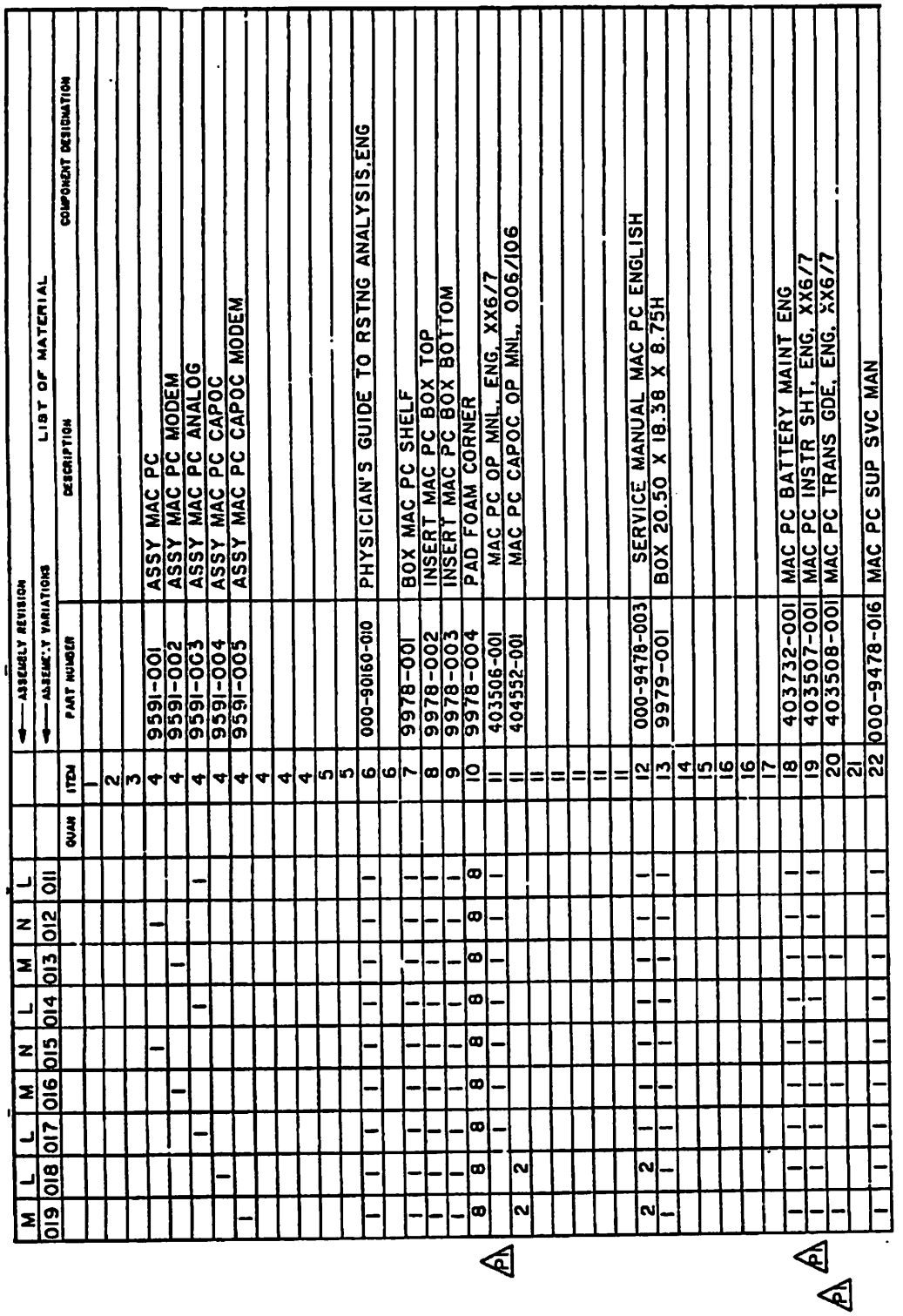
Domestic MAC PC Upper-Level Parts List PN 90056-0XXP1

M	N	L	M	N	M	L	L	L	M	N	QUAN	ITEM	PART NUMBER	DESCRIPTION	COMPONENT DESIGNATION
← ASSEMBLY REVISION															
← ASSEMBLY VARIATIONS														LIST OF MATERIAL	
010	009	008	007	006	005	004	003	002	001			1			
												2			
												3			
	1			1						1	4		9591-001	ASSY MAC PC	
1			1					1			4		9591-002	ASSY MAC PC MODEM	
		1					1				4		9591-003	ASSY MAC PC ANALOG	
						1					4		9591-004	ASSY MAC PC CAPOC	
					1						4		9591-005	ASSY MAC PC CAPOC MODEM	
											4				
											4				
											5				
											5				
1	1	1	1	1	1	1	1	1	1	1	6		000-90160-010	PHYSICIANS GUIDE TO RSTNG ANALYSIS,ENG	
											6				
1	1	1	1	1	1	1	1	1	1	1	7		9978-001	BOX MAC PC SHELF	
1	1	1	1	1	1	1	1	1	1	1	8		9978-002	INSERT MAC PC BOX TOP	
1	1	1	1	1	1	1	1	1	1	1	9		9978-003	INSERT MAC PC BOX BOTTOM	
8	8	8	8	8	8	8	8	8	8	8	10		9978-004	PAD FOAM CORNER	
1	1	1	1	1	1		1	1	1	1	11		403506-001	MAC PC OP MNL, ENG, XX6/7	
					2	2					11		404552-001	MAC PC CAPOC OP MNL, 006/106	
											11				
											11				
											11				
											11				
1	1	1	1	1	2	2	1	1	1	1	12		000-9478-003	SERVICE MANUAL MAC PC ENGLISH	
1	1	1	1	1	1	1	1	1	1	1	13		9979-001	BOX 20.50 X 18.38 X 8.75H	
											14				
											15				
											16				
											16				
											17				
1	1	1	1	1	1	1	1	1	1	1	18		403732-001	MAC PC BATTERY MAINT ENG	
1	1	1	1	1	1	1	1	1	1	1	19		403507-001	MAC PC INSTR SHT, ENG, XX6/7	
1			1		1		1				20		403508-001	MAC PC TRANS GDE, ENG, XX6/7	
											21				
1	1	1	1	1	1	1	1	1	1	1	22		000-9478-016	MAC PC SUP SVC MAN	

P1 P1 P1

1. OPERATOR'S MANUALS ARE TO REFLECT CURRENT SOFTWARE EDITION.

Domestic MAC PC Upper-Level Parts List PN 90056-0XXP1

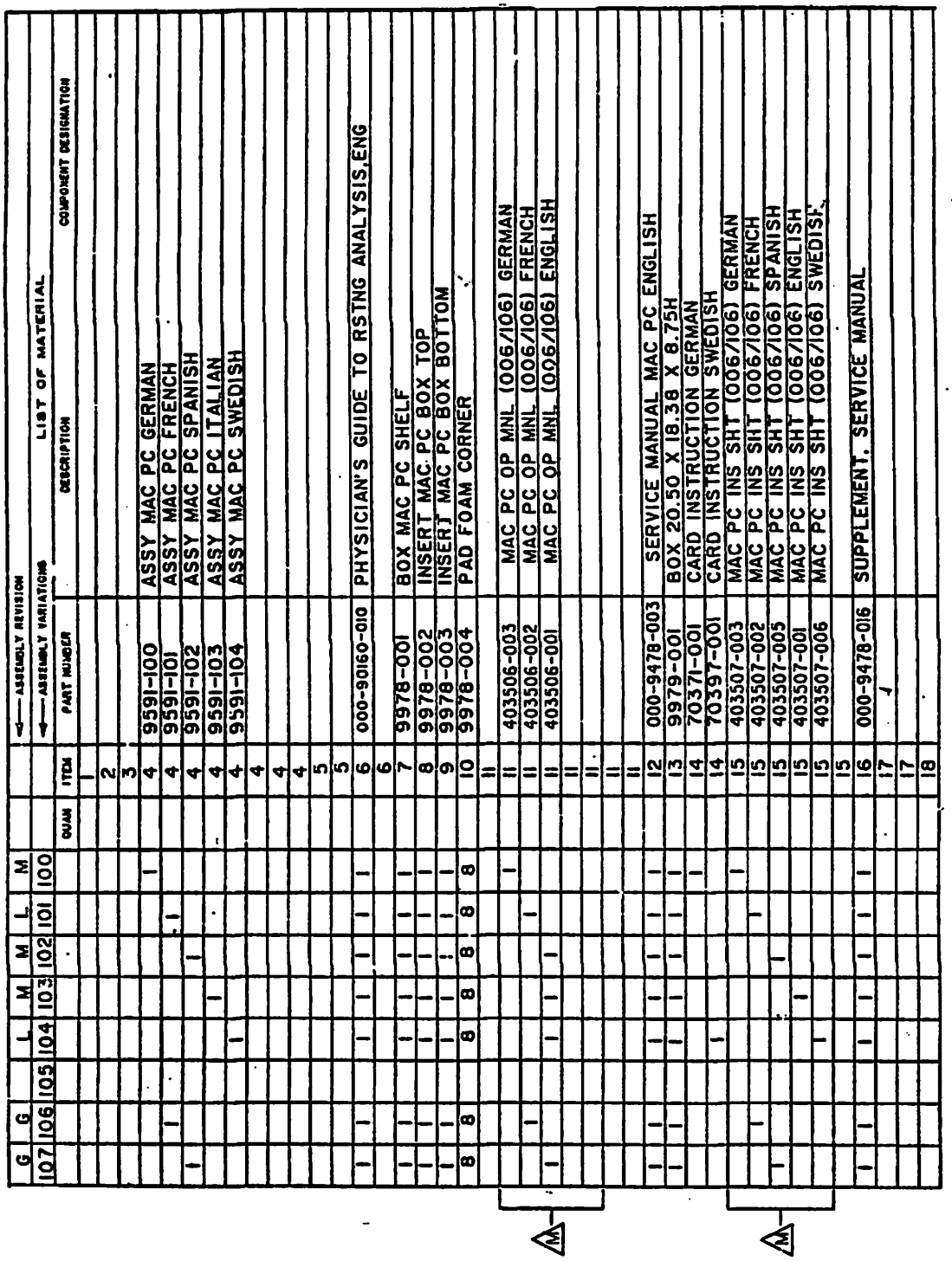


M	L	L	M	N	L	M	N	L	← ASSEMBLY REVISION		
019	018	017	016	015	014	013	012	011	← ASSEM'Y VARIATIONS	LIST OF MATERIAL	
									QUAN	ITEM	PART NUMBER	DESCRIPTION	COMPONENT DESIGNATION
										1			
										2			
										3			
									4	4	9591-001	ASSY MAC PC	
									4	4	9591-002	ASSY MAC PC MODEM	
									4	4	9591-003	ASSY MAC PC ANALOG	
									4	4	9591-004	ASSY MAC PC CAPOC	
									4	4	9591-005	ASSY MAC PC CAPOC MODEM	
										4			
										4			
										4			
										5			
										5			
										6	000-90160-010	PHYSICIAN'S GUIDE TO RSTNG ANALYSIS,ENG	
										6			
										7	9978-001	BOX MAC PC SHELF	
										8	9978-002	INSERT MAC PC BOX TOP	
										9	9978-003	INSERT MAC PC BOX BOTTOM	
										10	9978-004	PAD FOAM CORNER	
										11	403506-001	MAC PC OP MNL, ENG, XX6/7	
										11	404552-001	MAC PC CAPOC OP MNL, 006/106	
										11			
										11			
										11			
										11			
										12	000-9478-003	SERVICE MANUAL MAC PC ENGLISH	
										13	9979-001	BOX 20.50 X 18.38 X 8.75H	
										14			
										15			
										16			
										16			
										17			
										18	403732-001	MAC PC BATTERY MAINT ENG	
										19	403507-001	MAC PC INSTR SHT, ENG, XX6/7	
										20	403508-001	MAC PC TRANS GDE, ENG, XX6/7	
										21			
										22	000-9478-016	MAC PC SUP SVC MAN	

ASSY •	ECO•	DESCRIPTION
90056-001	18236	US/CA
90056-002	18269	MODEM
90056-003	18236	ANALOG
90056-004	18269	CAPOC
90056-005	18236	CAPOC MODEM
90056-006	18236	240V
90056-007	18269	240V MODEM
90056-008	18236	240V ANALOG
90056-009	18236	100V

ASSY •	ECO•	DESCRIPTION
90056-010	18269	100V MODEM
90056-011	18236	100V ANALOG
90056-012	18236	200V
90056-013	18269	200V MODEM
90056-014	18236	200V ANALOG
90056-015	18236	220V
90056-016	18269	220V MODEM
90056-017	18236	220V ANALOG
90056-018	18269	220V CAPOC
90056-019	18236	220V CA MOD

International MAC PC Upper-Level Parts List — PN 90056-10XM



G 107	G 106	L 105	L 104	M 103	M 102	L 101	M 100	QUAN	ITEM	PART NUMBER	DESCRIPTION	COMPONENT DESIGNATION
									1			
									2			
									3			
							1		4	9591-100	ASSY MAC PC GERMAN	
		1							4	9591-101	ASSY MAC PC FRENCH	
	1				1				4	9591-102	ASSY MAC PC SPANISH	
1				1					4	9591-103	ASSY MAC PC ITALIAN	
			1						4	9591-104	ASSY MAC PC SWEDISH	
									4			
									4			
									4			
									5			
									5			
1	1			1	1	1	1		6	000-90160-010	PHYSICIAN'S GUIDE TO RSTNG ANALYSIS,ENG	
									6			
	1		1	1	1	1	1		7	9978-001	BOX MAC PC SHELF	
	1		1	1	1	1	1		8	9978-002	INSERT MAC PC BOX TOP	
1	1		1	1	1	1	1		9	9978-003	INSERT MAC PC BOX BOTTOM	
8	8		8	8	8	8	8		10	9978-004	PAD FOAM CORNER	
									11			
							1		11	403506-003	MAC PC OP MNL (006/106) GERMAN	
	1					1			11	403506-002	MAC PC OP MNL (006/106) FRENCH	
1			1	1	1				11	403506-001	MAC PC OP MNL (006/106) ENGLISH	
									11			
									11			
									11			
1	1		1	1	1	1	1		12	000-9478-003	SERVICE MANUAL MAC PC ENGLISH	
1	1		1	1	1	1	1		13	9979-001	BOX 20.50 X 18.38 X 8.75H	
							1		14	70371-001	CARD INSTRUCTION GERMAN	
			1						14	70397-001	CARD INSTRUCTION SWEDISH	
							1		15	403507-003	MAC PC INS SHT (006/106) GERMAN	
	1					1			15	403507-002	MAC PC INS SHT (006/106) FRENCH	
	1			1					15	403507-005	MAC PC INS SHT (006/106) SPANISH	
					1				15	403507-001	MAC PC INS SHT (006/106) ENGLISH	
			1						15	403507-006	MAC PC INS SHT (006/106) SWEDISH	
									15			
1	1		1	1	1	1	1		16	000-9478-016	SUPPLEMENT, SERVICE MANUAL	
									17			
									17			
									18			

ASSY #	ECO#	DESCRIPTION
90056-100	18423	GERMAN
90056-101	18423	FRENCH
90056-102	18423	SPANISH
90056-103	18423	ITALIAN
90056-104	18423	SWEDISH
90056-105		SERBO
90056-106	18423	FRENCH 120V
90056-107	18423	SPANISH 120V

G 117	G 116	115	L 114	M 113	M 112	L 111	M 110	QUAN	ITEM	PART NUMBER	DESCRIPTION	COMPONENT DESIGNATION
									1			
									2			
									3			
							1		4	9591-110	ASSY MAC PC GERMAN MODEM	
	1					1			4	9591-111	ASSY MAC PC FRENCH MODEM	
1					1				4	9591-112	ASSY MAC PC SPANISH MODEM	
				1					4	9591-113	ASSY MAC PC ITALIAN MODEM	
			1						4	9591-114	ASSY MAC PC SWEDISH MODEM	
									4			
									4			
									4			
									5			
									5			
1	1		1	1	1	1	1		6	000-90160-010	PHYSICIAN'S GUIDE RSTNG ANALYSIS,ENG	
									6			
1	1		1	1	1	1	1		7	9978-001	BOX MAC PC SHELF	
1	1		1	1	1	1	1		8	9978-002	INSERT MAC PC BOX TOP	
1	1		1	1	1	1	1		9	9978-003	INSERT MAC PC BOX BOTTOM	
8	8		8	8	8	8	8		10	9978-004	PAD FOAM CORNER	
									11			
							1		11	403506-003	MAC PC OP MNL (006/106) GERMAN	
	1					1			11	403506-002	MAC PC OP MNL (006/106) FRENCH	
1			1	1	1				11	403506-001	MAC PC OP MNL (006/106) ENGLISH	
									11			
									11			
									11			
									11			
1	1		1	1	1	1	1		12	000-9478-003	SERVICE MANUAL MAC PC ENGLISH	
1	1		1	1	1	1	1		13	9979-001	BOX 20.50 X 18.38 X 8.75H	
							1		14	70371-001	CARD INSTRUCTION GERMAN	
							1		15	403507-003	MAC PC INS SHT (006/106) GERMAN	
	1					1			15	403507-002	MAC PC INS SHT (006/106) FRENCH	
1					1				15	403507-005	MAC PC INS SHT (006/105) SPANISH	
				1					15	403507-001	MAC PC INS SHT (006/106) ENGLISH	
			1						15	403507-006	MAC PC INS SHT (006/106) SWEDISH	
									15			
1	1		1	1	1	1	1		16	000-9478-016	SUPPLEMENT, SERVICE MANUAL	
									17			
									17			
									18			

NOTE: 1. ITEM 6 SHIP ONE PER SALES ORDER NOT ONE PER UNIT.

ASSY #	ECO#	DESCRIPTION
90056-110	18423	GERMAN MODEM
90056-111	18423	FRENCH MODEM
90056-112	18423	SPANISH MODEM
90056-113	18423	ITALIAN MODEM
90056-114	18423	SWEDISH MODEM
90056-115		SERBO MODEM
90056-116	18423	FRENCH MODEM 120V
90056-117	18423	SPANISH MODEM 120V

International MAC PC Upper-Level Parts List PN 90056-12XL1

G 127	G 126	K 125	J 124	J 123	K 122	J 121	K 120	QUAN	ITEM	PART NUMBER	DESCRIPTION	COMPONENT DESIGNATION
									1			
									2			
									3			
							I	4		9591-120	ASSY MAC PC GERMAN ANA/SER	
		I						4		9591-121	ASSY MAC PC FRENCH ANA/SER	
						I		4		9591-122	ASSY MAC PC SPANISH ANA/SER	
	I				I			4		9591-123	ASSY MAC PC ITALIAN ANA/SER	
				I				4		9591-124	ASSY MAC PC SWEDISH ANA/SER	
			I					4		9591-125	ASSY MAC PC SERBO ANA/SER	
		I						4				
								4				
								5				
								5				
I	I	I	I	I	I	I	I	6		000-90160-010	PHYSICIAN'S GUIDE TO RSTNG ANALYSIS.ENG	
								6				
I	I	I	I	I	I	I	I	7		9978-001	BOX MAC PC SHELF	
I	I	I	I	I	I	I	I	8		9978-002	INSERT MAC PC BOX TOP	
I	I	I	I	I	I	I	I	9		9978-003	INSERT MAC PC BOX BOTTOM	
8	8	8	8	8	8	8	8	10		9978-004	PAD FOAM CORNER	
								11				
							I	11		403506-003	MAC PC OP MNL (006/106) GERMAN	
	I					I		11		403506-002	MAC PC OP MNL (006/106) FRENCH	
I		I	I	I	I			11		403506-001	MAC PC OP MNL, ENG, XX6/7	
								11				
								11				
								11				
I	I	I	I	I	I	I	I	12		000-9478-003	SERVICE MANUAL MAC PC ENGLISH	
I	I	I	I	I	I	I	I	13		9979-001	BOX 20.50 X 18.38 X 8.75H	
							I	14		70371-001	CARD INSTRUCTION GERMAN	
							I	15		403507-003	MAC PC INS SHT (006/106) GERMAN	
	I					I		15		403507-002	MAC PC INS SHT (006/106) FRENCH	
I					I			15		403507-005	MAC PC INS SHT (006/106) SPANISH	
				I				15		403507-001	MAC PC INS SHT (006/106) ENGLISH	
			I					15		403507-006	MAC PC INS SHT (006/106) SWEDISH	
								15				
								16				
								16				
								17				
I	I	I	I	I	I	I	I	18		000-9478-016	SERVICE MANUAL SUPPLEMENT	

⚠1

ASSY #	ECO#	DESCRIPTION
90056-120	18423	GERMAN ANA/SER
90056-121	18423	FRENCH ANA/SER
90056-122	18423	SPANISH ANA/SER
90056-123	18423	ITALIAN ANA/SER
90056-124	18423	SWEDISH ANA/SER
90056-125	18423	SERBO ANA/SER
90056-126	18423	FRENCH ANA/SER 120V
90056-127	18423	SPANISH ANA/SER 120V

Domestic MAC PC Assembly Revisions PN 9591-001

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	5	45074-408	Added item 5	
	6	4656-412	Added item 6	
	8	58614-004	Added item 8	
	13	85676-001	Added item 13	
	16	4846-006	Added item 16	
C	2	300027-001	Changed to 300027-002	Changed to 1 megabyte EPROMs.
	3	300041-001	Delete item 3	
D	5	45074-408	Delete item 5	Remove expansion board, it is not necessary with the 1 megabyte EPROMs.
	6	4656-412	Delete item 6	
	13	85676-001	Delete item 13	
	16	4846-006	Delete item 16	
E	2	300027-002	Changed to 300027-003	This revision added new software that provided new features.
F	9	70206-001	Changed to 404525-001	
G	2	300027-003	Changed to 300027-005	New software release: version 107A.

Domestic Modem MAC PC Assembly Revisions PN 9591-002

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	5	45074-408	Changed quant from 1 to 2	
	6	4656-412	Changed quant from 1 to 3	
C	2	300027-001	Changed to 300027-002	Changed to 1 megabyte EPROMs.
	3	300041-001	Delete item 3	
D	2	300027-002	Changed to 300027-003	This revision added new software that provided new features.
E	9	70206-001	Changed to 404525-001	
F	2	300027-003	Changed to 300027-005	New software release: version 107A.

Domestic Analog MAC PC Assembly Revisions PN 9591-003

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	13	85843-001	Changed to 85843-002	
C	2	300027-001	Changed to 300027-002	Changed to 1 megabyte EPROMs.
	3	300041-001	Delete item 3	
D	17	400089-001	Add, Quant-1	
	18	45176-106	Add, Quant-2	
E				This revision cleaned up some drawing problems.
F	2	300027-002	Changed to 300027-003	This revision added new software that provided new features.
G	9	70206-001	Changed to 404525-001	
H	2	300027-003	Changed to 300027-005	New software release: version 107A.

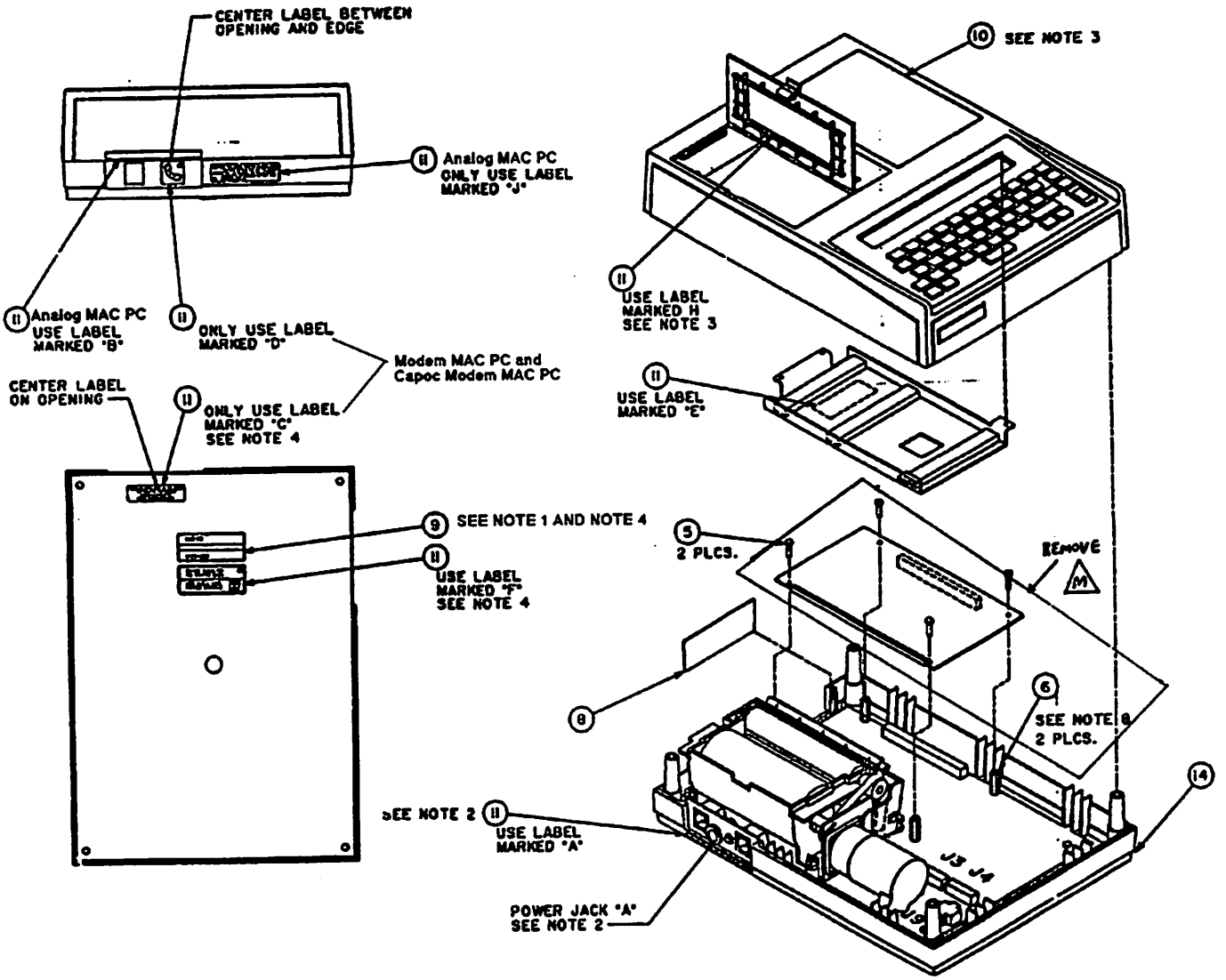
Domestic CAPOC MAC PC Assembly Revisions PN 9591-004

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	5	45074-408	Added item 5	
	6	4656-412	Added item 6	
	8	58614-004	Added item 8	
	13	85676-001	Added item 13	
	16	4846-006	Added item 16	
C	4	300065-001	Changed to 300065-002	New software release: CAPOC versions 006A and 106A.
	5	45074-408	Delete item 5	
	6	4656-412	Delete item 6	
	13	85676-001	Delete item 13	
	16	4846-006	Delete item 16	
D	9	70206-001	Changed to 404525-001	

Domestic CAPOC Modem MAC PC Assembly Revisions PN 9591-005

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	5	45074-408	Changed quant from 1 to 2	
	6	4656-412	Changed quant from 1 to 3	
C	4	300065-001	Changed to 300065-002	New software release: CAPOC versions 006A and 106A.
D	9	70206-001	Changed to 404525-001	

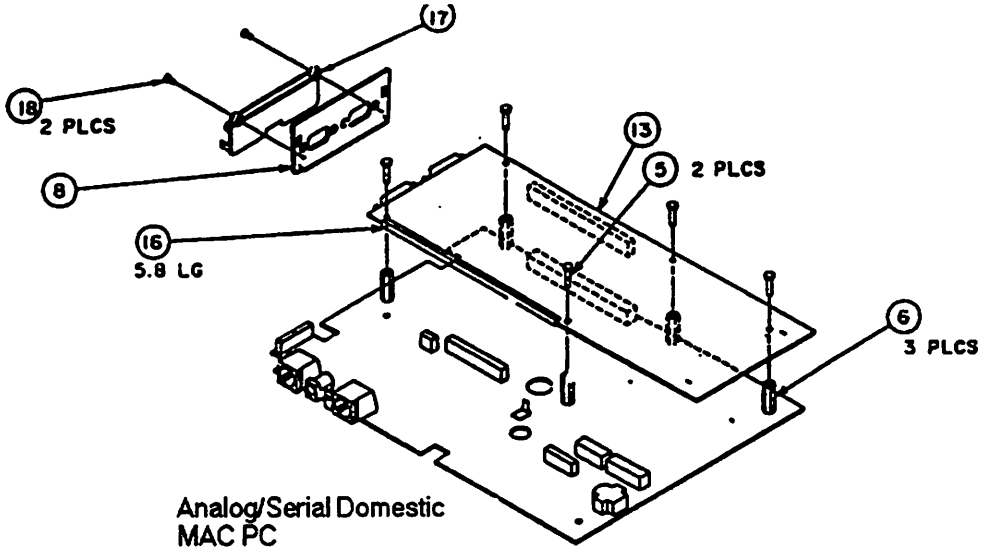
Final Domestic MAC PC Assembly PN 9591-0XXN



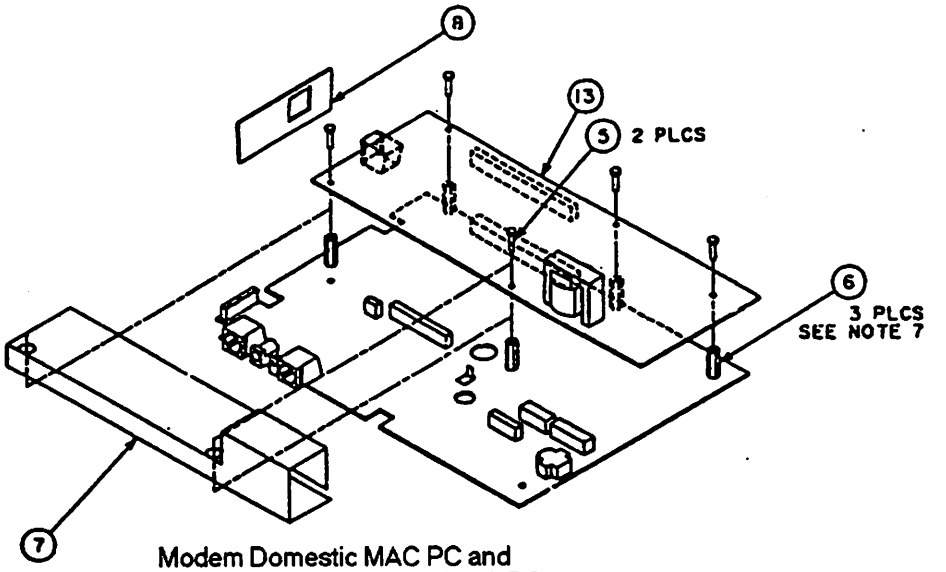
Final Domestic MAC PC Assembly PN 9591-0XXN

NOTES

1. MODEL/SERIAL LABEL ON BASE MUST BE MARKED AS FOLLOWS: MAC PC (SERIAL # TO BE DETERMINED)
2. ITEM 11 (LABEL "A") TO BE ATTACHED AS FOLLOWS "PM" TEXT TO BE CENTERED ON CONN MARKED POWER JACK "A".
3. LABEL TO BE RIGHT READING WHEN UNIT IS VIEWED FROM TOP SIDE FACING KEYBOARD.
4. LABELS TO BE RIGHT READING WHEN UNIT IS VIEWED FROM UNDERSIDE. WITH KEYBOARD TOWARD USER.
5. REMOVE 3 SCREWS, 45074-408, REPLACE THEM WITH ITEM 6, INSTALL CIRCUIT BOARD THEN REPLACE 3 SCREWS THRU CIRCUIT BOARD INTO ITEM 6



Analog/Serial Domestic MAC PC



Modem Domestic MAC PC and Capoc Modem Domestic MAC PC

Final Domestic MAC PC Assembly Parts List PN 9591-0XXN

9591-001	Domestic MAC PC
9591-002	Domestic Modem MAC PC
9591-003	Domestic Analog/Serial MAC PC
9591-004	Domestic CAPOC MAC PC
9591-005	Domestic CAPOC Modem MAC PC

C	C..	H	F	G		←ASSEMBLY REVISION		
005	004	003	002	001		→ASSEMBLY VARIATIONS	LIST OF MATERIAL	
				QUAN	ITEM	PART NUMBER	DESCRIPTION	COMPONENT DESCRIPTION
1	-	-	1	-	1	1809-001	ADAPTER PLUG ASSY	NOT SHOWN
-	-	1	1	1	2	300027-005	F-R MAC PC V107 ENGLISH	
					3			
1	1	-	-	-	4	300065-002	F-R MAC PC V106 CAPOC	
2	-	2	2	-	5	45074-408	SCREW BDGH 4-40X1/4	
3	-	3	3	-	6	4656-412	SPACER M/F 1/4 HEX 4-40 X 3/4	
1	-	-	1	-	7	58055-001	INSULATOR MAC PC MODEM BD	
1	-	-	1	-	8	58614-003	PANEL MODEM MAC PC	
-	1	-	-	1	8	58614-004	PANEL TRIM MAC PC	
-	-	1	-	-	8	58614-005	PANEL ANALOG MAC PC	
1	1	1	1	1	9	404525-001	LABEL MODEL/SERIAL NO.	
1	1	1	1	1	10	70282-101	NAMEPLATE OPERATE INSTRUCTIONS	
1	1	1	1	1	11	70458-001	LABELS MAC PC	
1	-	-	1	-	12	80159-014	CABLE TEL 4IC MODULAR PLUG 14F	NOT SHOWN
1	-	-	1	-	13	85637-001	PCB MAC PC MODEM	
					13			
-	-	1	-	-	13	85843-002	PCB MAC PC ANALOG/SERIAL	
1	1	1	1	1	14	88936-001	MAC PC ASSM	
-	1	-	-	1	15	SD9591-001	SCHEM MAC PC	
1	-	-	1	-	15	SD9591-002	SCHEM MAC PC MODEM	
-	-	1	-	-	15	SD9591-003	SCHEM MAC PC ANALOG	
-	-	.8	-	-	16	4846-006	GROMMET EXTR BLK CSG-06	
-	-	1	-	-	17	400089-001	COVER CONN MAC PC	
-	-	2	-	-	18	45176-106	SCREW ITAP FILHD 1-42 X 3/16	

German MAC PC Assembly Revisions PN 9591-100

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	2	4656-412	Added item 2	
	8	85676-001	Added item 8	
	9	45074-408	Added item 9	
	10	4846-006	Added item 10	
	11	58614-004	Added item 11	
C	47	300052-001	Changed to 300052-002	New software based on English version 5C released.
D	1	300052-002	Changed to 300052-003	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
	2	4656-412	Delete item 2	
	8	85676-001	Delete item 8	
	9	45074-408	Delete item 9	
	10	4846-006	Delete item 10	
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

French MAC PC Assembly Revisions PN 9591-101

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	2	4656-412	Added item 2	
	8	85676-001	Added item 8	
	9	45074-408	Added item 9	
	10	4846-006	Added item 10	
	11	58614-004	Added item 11	
C	47	300046-001	Changed to 300046-002	New software based on English version 5C released.
D	1	300046-002	Changed to 300046-003	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
	2	4656-412	Delete item 2	
	8	85676-001	Delete item 8	
	9	45074-408	Delete item 9	
	10	4846-006	Delete item 10	
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

Spanish MAC PC Assembly Revisions PN 9591-102

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	2	4656-412	Added item 2	
	8	85676-001	Added item 8	
	9	45074-408	Added item 9	
	10	4846-006	Added item 10	
	11	58614-004	Added item 11	
C	1	300057-001	Changed to 300057-003	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
	2	4656-412	Delete item 2	
	8	85676-001	Delete item 8	
	9	45074-408	Delete item 9	
	10	4846-006	Delete item 10	
D				No information available on this revision.
E	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

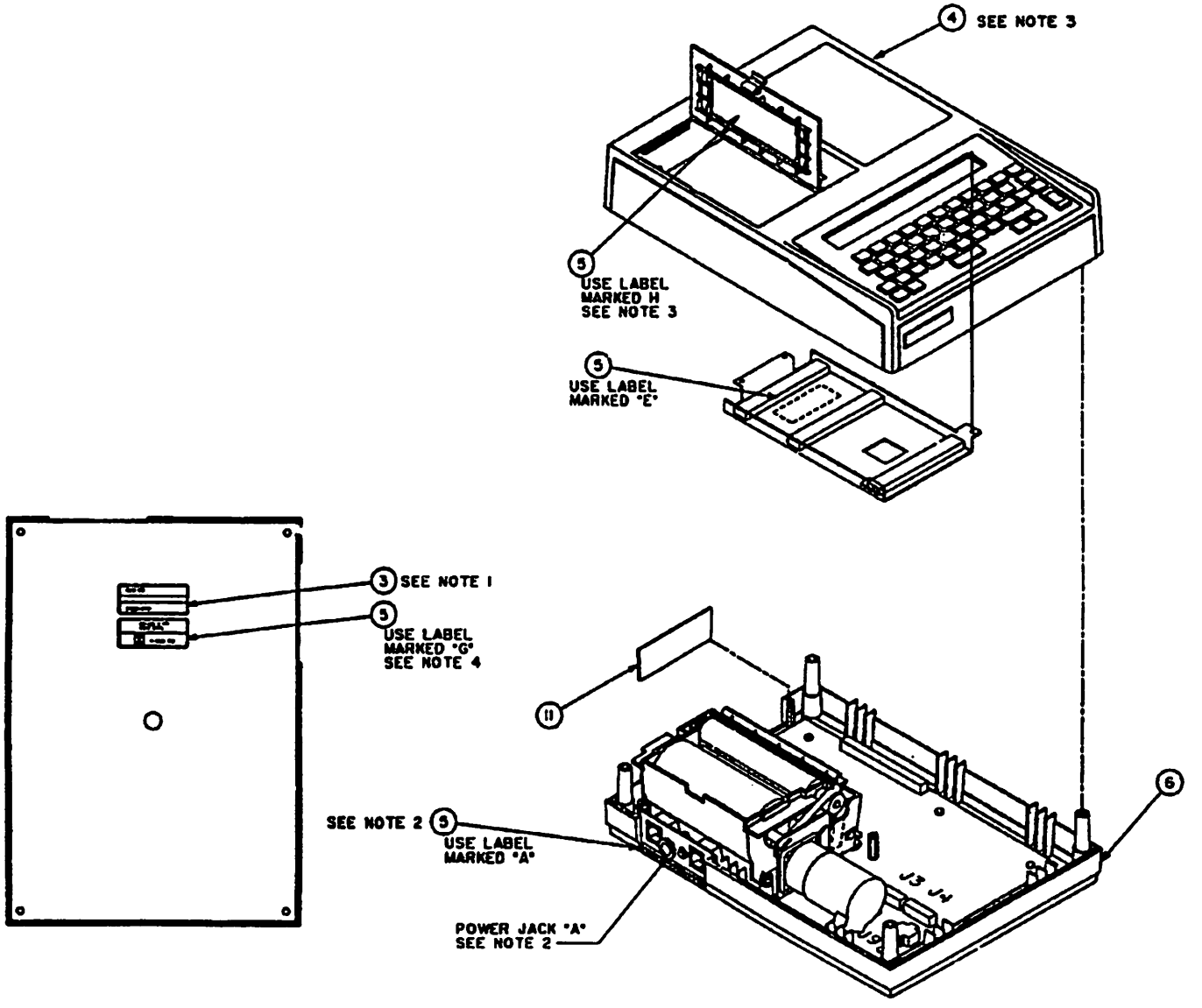
Italian MAC PC Assembly Revisions PN 9591-103

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	2	4656-412	Added item 2	
	8	85676-001	Added item 8	
	9	45074-408	Added item 9	
	10	4846-006	Added item 10	
	11	58614-004	Added item 11	
C	47	300058-001	Changed to 300058-002	New software based on English version 5C released.
D	1	300058-002	Changed to 300058-003	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
	2	4656-412	Delete item 2	
	8	85676-001	Delete item 8	
	9	45074-408	Delete item 9	
	10	4846-006	Delete item 10	
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

Swedish MAC PC Assembly Revisions PN 9591-104

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	2	4656-412	Added item 2	
	8	85676-001	Added item 8	
	9	45074-408	Added item 9	
	10	4846-006	Added item 10	
	11	58614-004	Added item 11	
C				No information available on this revision.
D	1	300076-002	Changed to 300076-003	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
	2	4656-412	Delete item 2	
	8	85676-001	Delete item 8	
	9	45074-408	Delete item 9	
	10	4846-006	Delete item 10	
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

International MAC PC Assembly PN 9591-10XH



NOTES

1. MODEL/SERIAL LABEL ON BASE MUST BE MARKED AS FOLLOWS: MAC PC
   (SERIAL # TO BE DETERMINED)

2. ITEM 5 (LABEL "A") TO BE ATTACHED AS FOLLOWS "PM" TEXT TO BE CENTERED ON CONN MARKED POWER JACK "A".

3. LABEL TO BE RIGHT READING WHEN UNIT IS VIEWED FROM TOP SIDE FACING KEYBOARD.

4. LABELS TO BE RIGHT READING WHEN UNIT IS VIEWED FROM UNDERSIDE WITH KEYBOARD TOWARD USER.

International MAC PC Assembly Parts Lists — PN 9591-10XH

9591-100	German MAC PC
9591-101	French MAC PC
9591-102	Spanish MAC PC
9591-103	Italian MAC PC
9591-104	Swedish MAC PC

F	F	E	F	F		←ASSEMBLY REVISION		
104	103	102	101	100		←ASSEMBLY VARIATIONS	LIST OF MATERIAL	
				QUAN	ITEM	PART NUMBER	DESCRIPTION	COMPONENT DESCRIPTION
-	-	-	-	1	1	300052-005	F-R MAC PC GERMAN V106	
-	-	-	1	-	1	300046-005	F-R MAC PC FRENCH V106	
-	-	1	-	-	1	300057-005	F-R MAC PC SPANISH V106	
-	1	-	-	-	1	300058-005	F-R MAC PC ITALIAN V106	
1	-	-	-	-	1	300076-005	F-R MAC PC SWEDISH V106	
					1			
					1			
					2			
1	1	1	1	1	3	404525-001	LABEL BLANK 2X3/4	
1	1	1	1	1	4	70282-102	NMPLT OP INSTRUCT MAC PC	
1	1	1	1	1	5	70458-001	LABELS MAC PC	
1	1	1	1	1	6	88936-001	MAC PC ASSM	
1	1	1	1	1	7	SD9591-001	SCHEM MAC PC	
					8			
					9			
					10			
1	1	1	1	1	11	58614-004	PANEL TRIM MAC PC	

German Modem MAC PC Assembly Revisions PN 9591-110

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B				No information available on this revision.
C	3	45074-408	Changed quant from 1 to 2	
	4	4656-412	Changed quant from 1 to 3	
D	1	300052-001	Changed to 300052-002	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

French Modem MAC PC Assembly Revisions PN 9591-111

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B				
C	3	45074-408	Changed quant from 1 to 2	
	4	4656-412	Changed quant from 1 to 3	
D	1	300046-001	Changed to 300046-003	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

Spanish Modem MAC PC Assembly Revisions PN 9591-112

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B				
C	3	45074-408	Changed quant from 1 to 2	
	4	4656-412	Changed quant from 1 to 3	
D	1	300057-001	Changed to 300057-003	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

Italian Modem MAC PC Assembly Revisions PN 9591-113

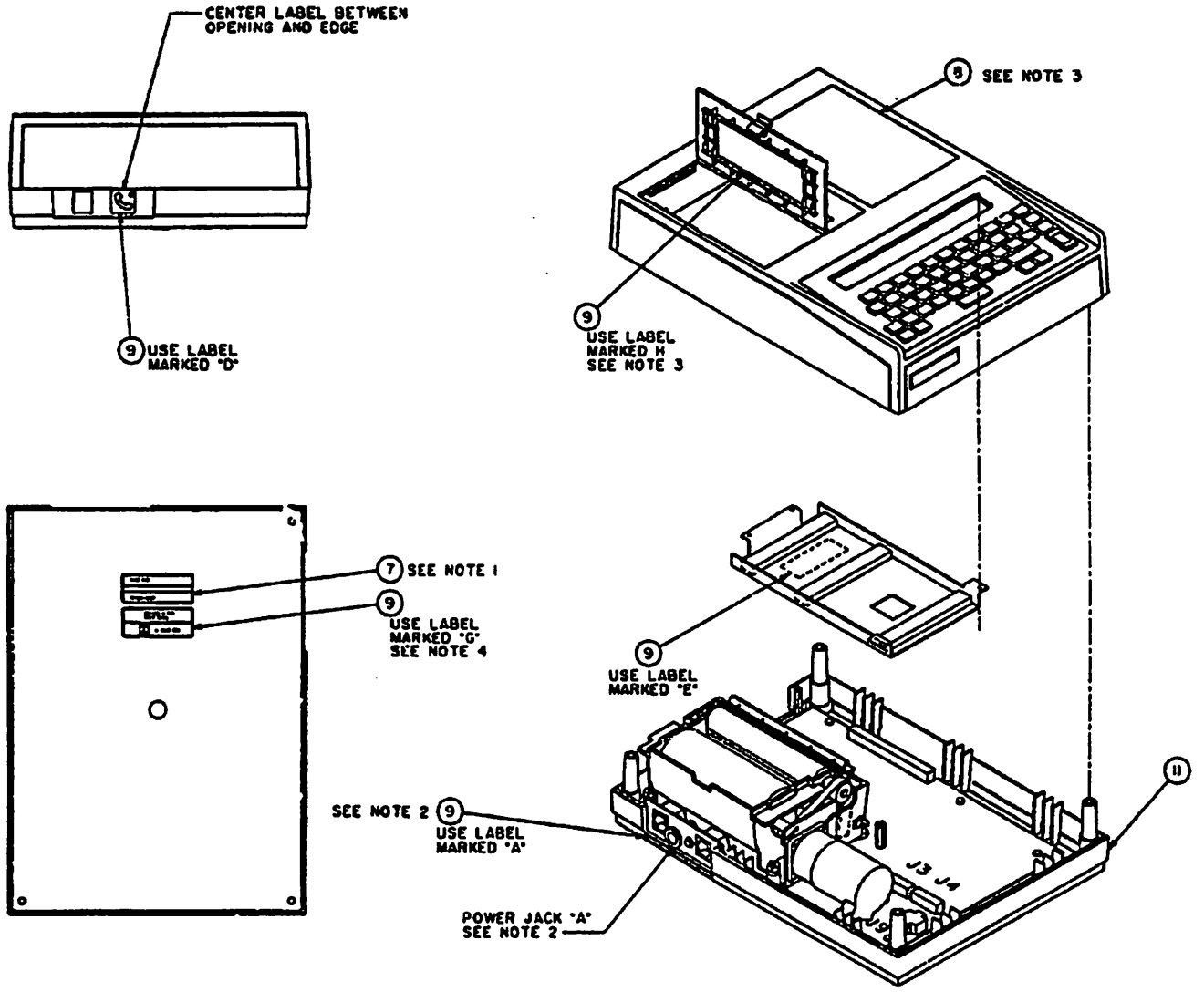
REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B				
C	3	45074-408	Changed quant from 1 to 2	
	4	4656-412	Changed quant from 1 to 3	
D	1	300058-002	Changed to 300058-003	Changed to software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

Swedish Modem MAC PC Assembly Revisions PN 9591-114

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of the assembly.
B	1	300076-001	Changed to 300076-002	A new release of Swedish software based on the English version 005C was released.
C	1	300076-002	Changed to 300076-003	Changed to software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
D				No information available on this revision.
E	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

NOTES

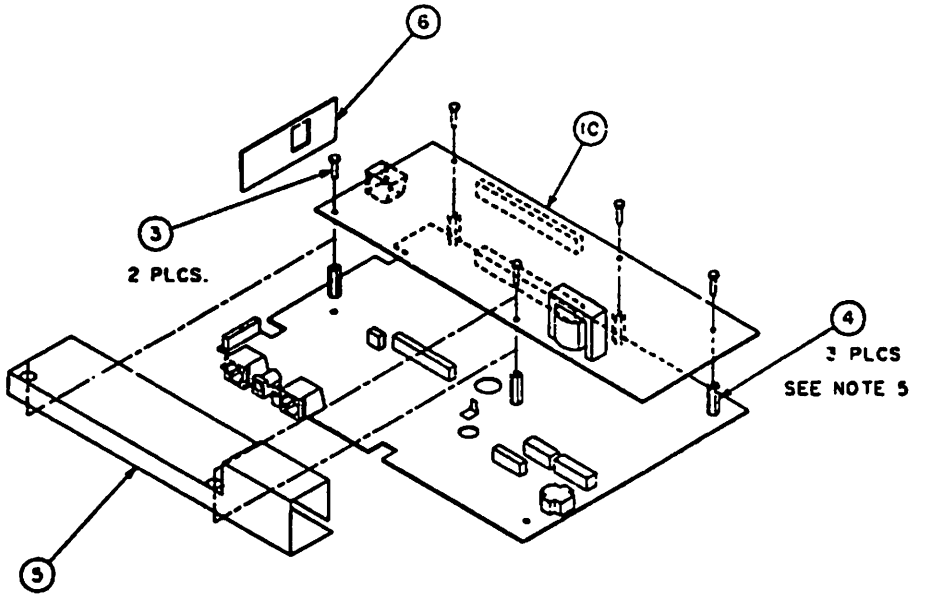
International Modem MAC PC PN 9591-11XJ



International Modem MAC PC PN 9591-11XJ

NOTES:

1. MODEL/SERIAL LABEL ON BASE MUST BE MARKED AS FOLLOWS: MAC PC (SERIAL # TO BE DETERMINED)
2. ITEM 9 (LABEL "A") TO BE ATTACHED AS FOLLOWS "PM" TEXT TO BE CENTERED ON CONN MARKED POWER JACK "A".
3. LABEL TO BE RIGHT READING WHEN UNIT IS VIEWED FROM TOP SIDE FACING KEYBOARD.
4. LABELS TO BE RIGHT READING WHEN UNIT IS VIEWED FROM UNDERSIDE. WITH KEYBOARD TOWARD USER.
5. REMOVE 3 SCREWS 45074-408. REPLACE THEM WITH ITEM 4. INSTALL CIRCUIT BOARD THEN REPLACE 3 SCREWS INSERTING THEM THRU CIRCUIT BOARD INTO ITEM 4.



International Modem MAC PC Parts List — PN 9591-11XJ

9591-110	German Modem MAC PC
9591-111	French Modem MAC PC
9591-112	Spanish Modem MAC PC
9591-113	Italian Modem MAC PC
9591-114	Swedish Modem MAC PC

E	F	F	F	F		← ASSEMBLY REVISIONS		
114	113	112	111	110		← ASSEMBLY VARIATIONS	LIST OF MATERIALS	
				QUAN	ITEM	PART NUMBER	DESCRIPTION	COMPONENT DESCRIPTION
-	-	-	-	1	1	300052-005	F-R MAC PC GERMAN V106	
-	-	-	1	-	1	300046-005	F-R MAC PC FRENCH V106	
-	-	1	-	-	1	300057-005	F-R MAC PC SPANISH V106	
-	1	-	-	-	1	300058-005	F-R MAC PC ITALIAN V106	
1	-	-	-	-	1	300076-005	F-R MAC PC SWEDISH V106	
					1			
					2			
2	2	2	2	2	3	45074-408	SCREW BDGH 4-40X1/4	
3	3	3	3	3	4	4656-412	SPACER M/F 1/4 HEX 4-40 X 3/4	
1	1	1	1	1	5	58055-001	INSULATOR MAC PC MODEM BD	
1	1	1	1	1	6	58614-003	PANEL MODEM PLAT MAC PC	
1	1	1	1	1	7	404525-001	LABEL BLANK 2X3/4	
1	1	1	1	1	8	70282-102	NAMEPLATE OPERATE INSTRUCTIONS	
1	1	1	1	1	9	70458-001	LABELS MAC PC	
1	1	1	1	1	10	85637-001	PCB MAC PC MODEM	
					10			
1	1	1	1	1	11	88936-001	MAC PC ASSM	
1	1	1	1	1	12	1809-001	ADAPTER PLUG ASSY	NOT SHOWN
1	1	1	1	1	13	80159-014	CABLE TEL 4IC MODULAR PLUG 14F	NOT SHOWN
1	1	1	1	1	14	SD9591-002	SCHEM MAC PC MODEM	

German Analog/Serial MAC PC Assembly Revisions PN 9591-120

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	13	400089-001	Add, Quant-1	
	14	45176-106	Add, Quant-2	
C	1	300052-002	Changed to 300052-003	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
D				This revision cleaned up some drawing problems.
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

French Analog/Serial MAC PC Assembly Revisions PN 9591-121

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly
B	13	400089-001	Add, Quant-1	
	14	45176-106	Add, Quant-2	
C	1	300046-002	Changed to 300046-003	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
D				This revision cleaned up some drawing problems.
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

Spanish Analog/Serial MAC PC Assembly Revisions PN 9591-122

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	13	400089-001	Add, Quant-1	
	14	45176-106	Add, Quant-2	
C	1	300057-002	Changed to 300057-003	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
D				This revision cleaned up some drawing problems.
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

Italian Analog/Serial MAC PC Assembly Revisions PN 9591-123

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	13	400089-001	Add, Quant-1	
	14	45176-106	Add, Quant-2	
C	1	300058-002	Changed to 300058-003	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
D				This revision cleaned up some drawing problems.
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

Swedish Analog/Serial MAC PC Assembly Revisions PN 9591-124

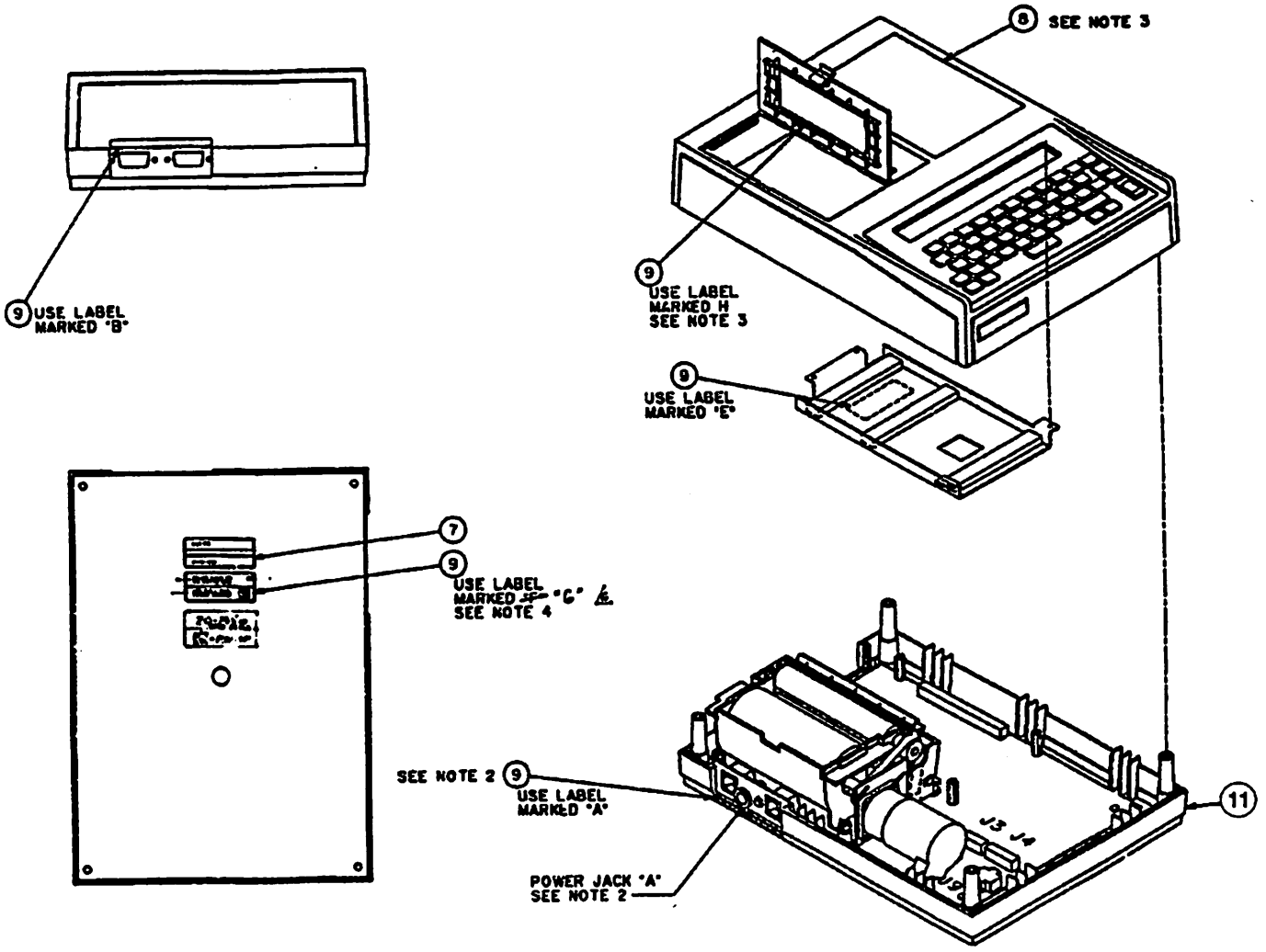
REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	13	400089-001	Add, Quant-1	
	14	45176-106	Add, Quant-2	
C	1	300076-002	Changed to 300076-003	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
D				This revision cleaned up some drawing problems.
E				No information available on this revision.
F	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

Serbo Analog/Serial MAC PC Assembly Revisions PN 9591-125

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B	13	400089-001	Add, Quant-1	
	14	45176-106	Add, Quant-2	
C	1	400781-001	Changed to 400781-002	Software based on English version 105C released. This revision included the removal of the memory expansion board as the new 1 Meg EPROMs do not require the board.
D				This revision cleaned up some drawing problems.
E	3	70206-001	Changed to 404525-001	This revision added a new bar code label.

NOTES

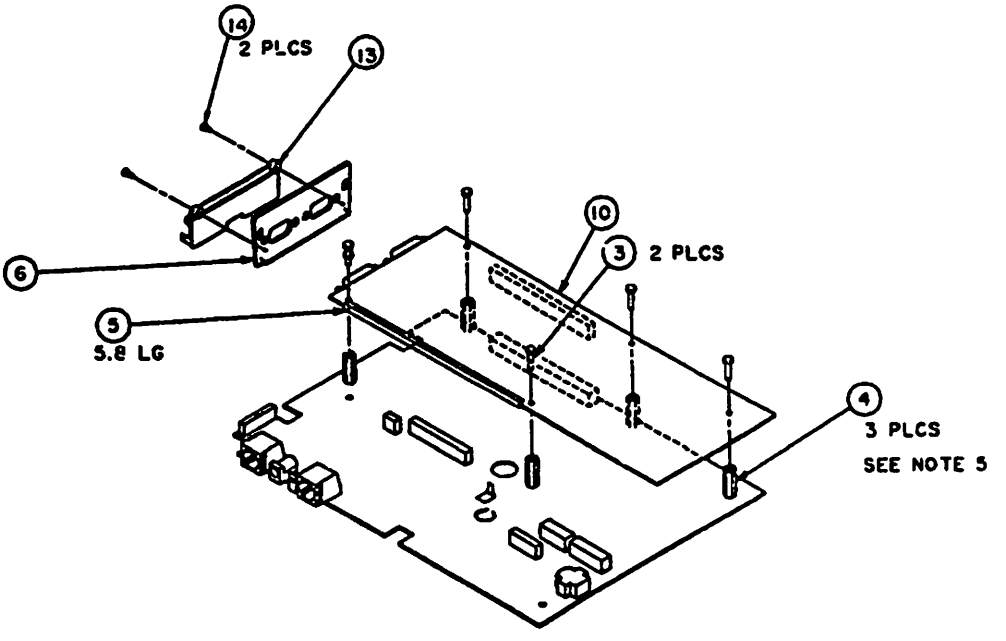
International Analog/Serial MAC PC Assembly PN 9591-12XG



International Analog/Serial MAC PC Assembly PN 9591-12XG

NOTES:

1. MODEL/SERIAL LABEL ON BASE MUST BE MARKED AS FOLLOWS: MAC PC (SERIAL # TO BE DETERMINED)
2. ITEM 9 (LABEL "A") TO BE ATTACHED AS FOLLOWS "PM" TEXT TO BE CENTERED ON CONN MARKED POWER JACK "A".
3. LABEL TO BE RIGHT READING WHEN UNIT IS VIEWED FROM TOP SIDE FACING KEYBOARD.
4. LABELS TO BE RIGHT READING WHEN UNIT IS VIEWED FROM UNDERSIDE. WITH KEYBOARD TOWARD USER.
5. REMOVE 3 SCREWS 45074-408. REPLACE THEM WITH ITEM 4. INSTALL CIRCUIT BOARD THEN REPLACE 3 SCREWS INSERTING THEM THRU CIRCUIT BOARD INTO ITEM 4.



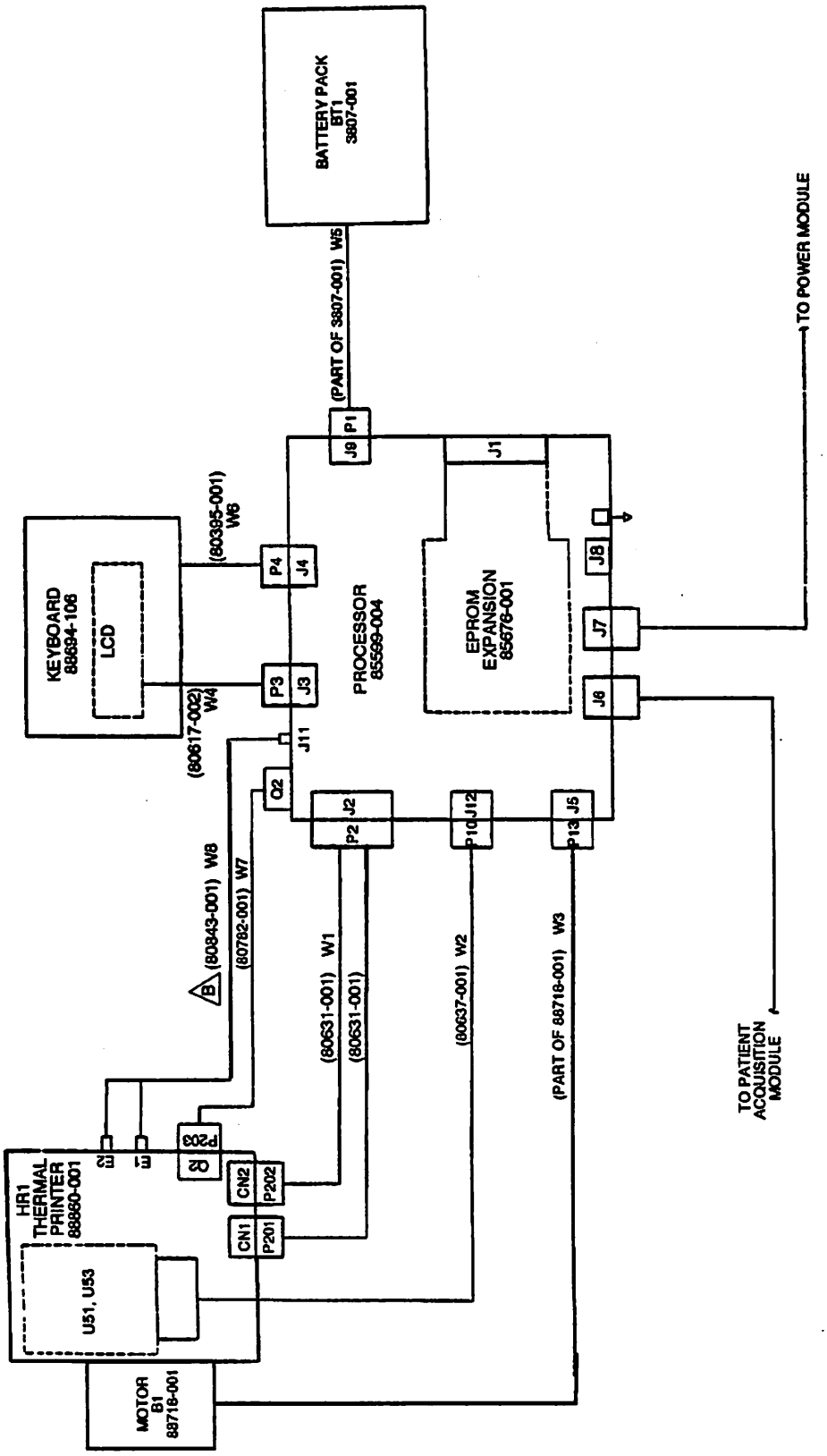
9591-120	German Analog/Serial MAC PC
9591-121	French Analog/Serial MAC PC
9591-122	Spanish Analog/Serial MAC PC
9591-123	Italian Analog/Serial MAC PC
9591-124	Swedish Analog/Serial MAC PC
9591-125	Serbo Analog/Serial MAC PC

E	F	F	F	F	F		← ASSEMBLY REVISIONS		
125	124	123	122	121	120		← ASSEMBLY VARIATIONS	LIST OF MATERIAL	
					QUAN	ITEM	PART NUMBER	DESCRIPTION	COMPONENT DESCRIPTION
-		-	-	-	1	1	300052-005	F-R MAC PC GERMAN V106	
-	-	-	-	1	-	1	300046-005	F-R MAC PC FRENCH V106	
-	-	-	1	-	-	1	300057-005	F-R MAC PC SPANISH V106	
-	-	1	-	-	-	1	300058-005	F-R MAC PC ITALIAN V106	
-	1	-	-	-	-	1	300076-005	F-R MAC PC SWEDISH V106	
1	-	-	-	-	-	1	400781-002	F-R MAC PC SERBO	
						2			
2	2	2	2	2	2	3	45074-408	SCREW BDGH 4-40X1/4	
3	3	3	3	3	3	4	4656-412	SPACER M/F 1/4 HEX 4-40 X 3/4	
.8	.8	.8	.8	.8	.8	5	4846-006	GROMMET EXTR BLK CSG-06	
1	1	1	1	1	1	6	58614-005	PANEL ANALOG MAC PC	
1	1	1	1	1	1	7	404525-001	LABEL BLACK 2X3/4	
1	1	1	1	1	1	8	70282-102	NMPLT OP INSTRUCT MAC PC BLANK	
1	1	1	1	1	1	9	70458-001	LABELS MAC PC	
1	1	1	1	1	1	10	85843-002	PCB MAC PC ANALOG/SERIAL	
						10			
1	1	1	1	1	1	11	88936-001	MAC PC ASSM	
1	1	1	1	1	1	12	SD9591-003	SCHEM MAC PC ANALOG	
1	1	1	1	1	1	13	400089-001	COVER CONN MAC PC	
2	2	2	2	2	2	14	45176-106	SCREW TAP FILHD 1-42 X 3/16	

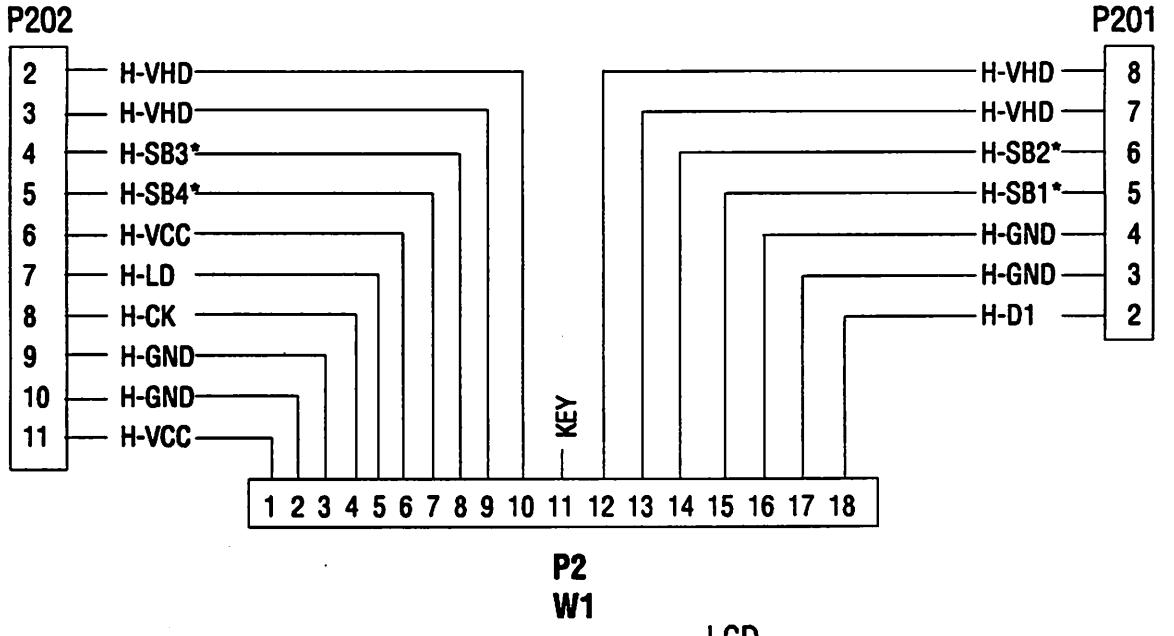
MAC PC Schematic Revisions SD9591-001

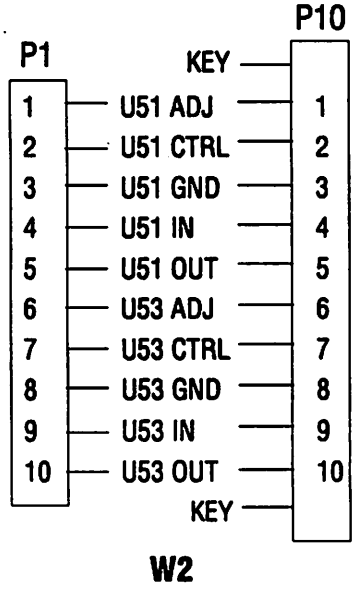
REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B				This revision corrected an error in the schematic for cable W8. W8 was shown as pn 80234-067. It is now correctly shown as pn 80843-001.

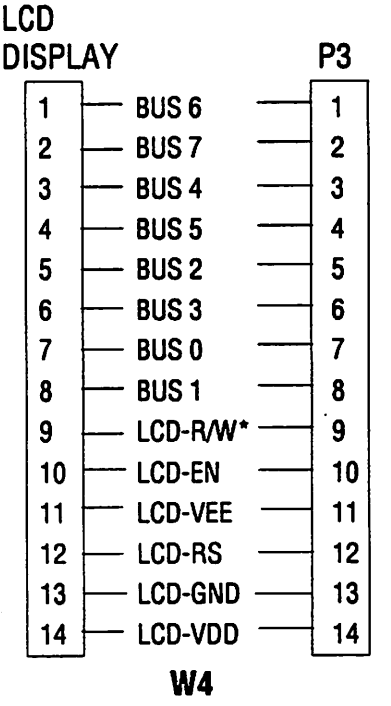
MAC PC Schematic SD9591-001B

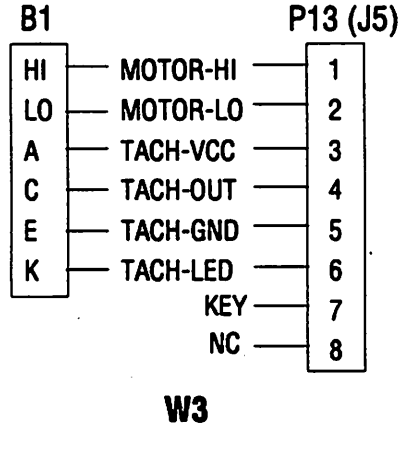


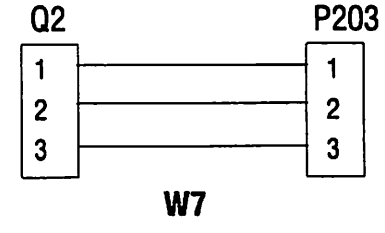
MAC PC Schematic SD9591-001B



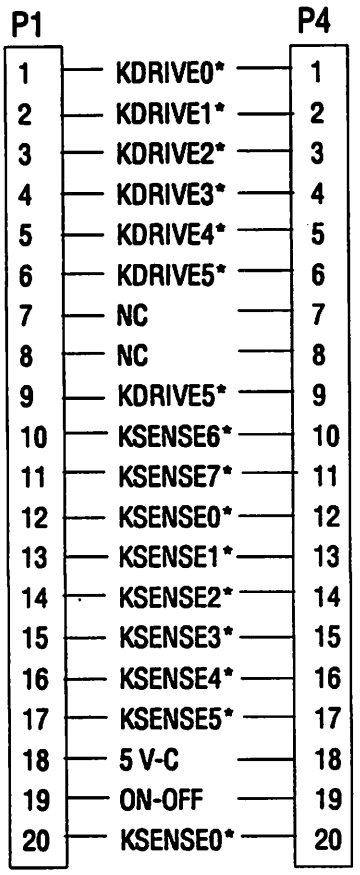




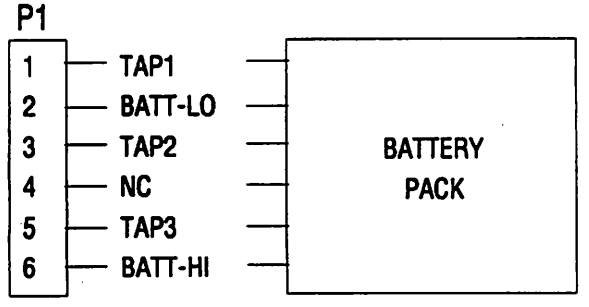




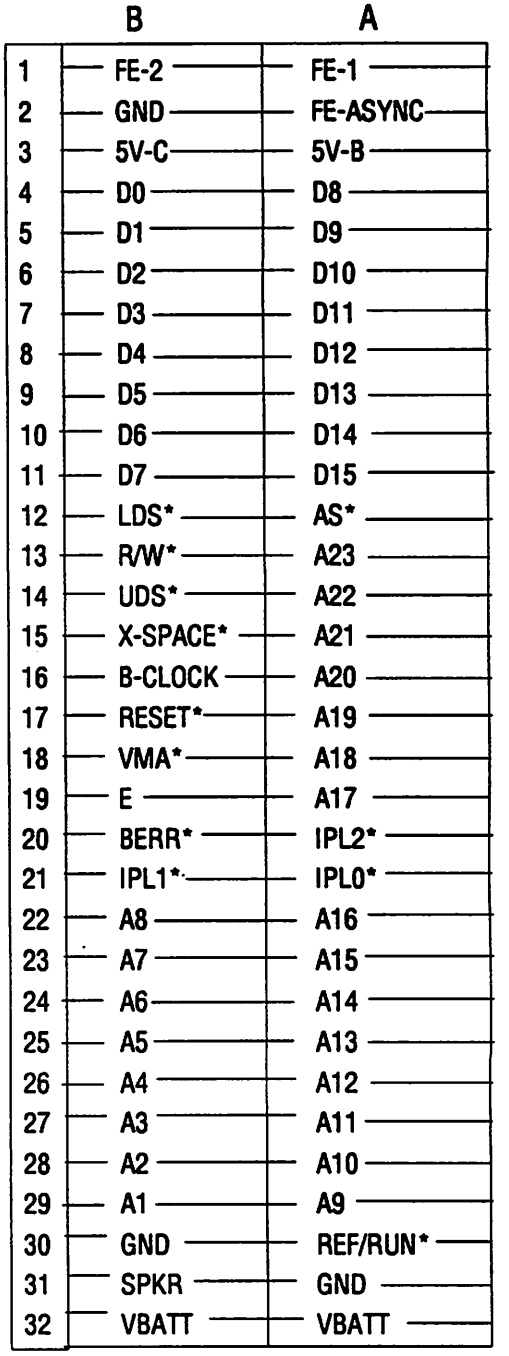
MAC PC Schematic SD9591-001B



W6



W5



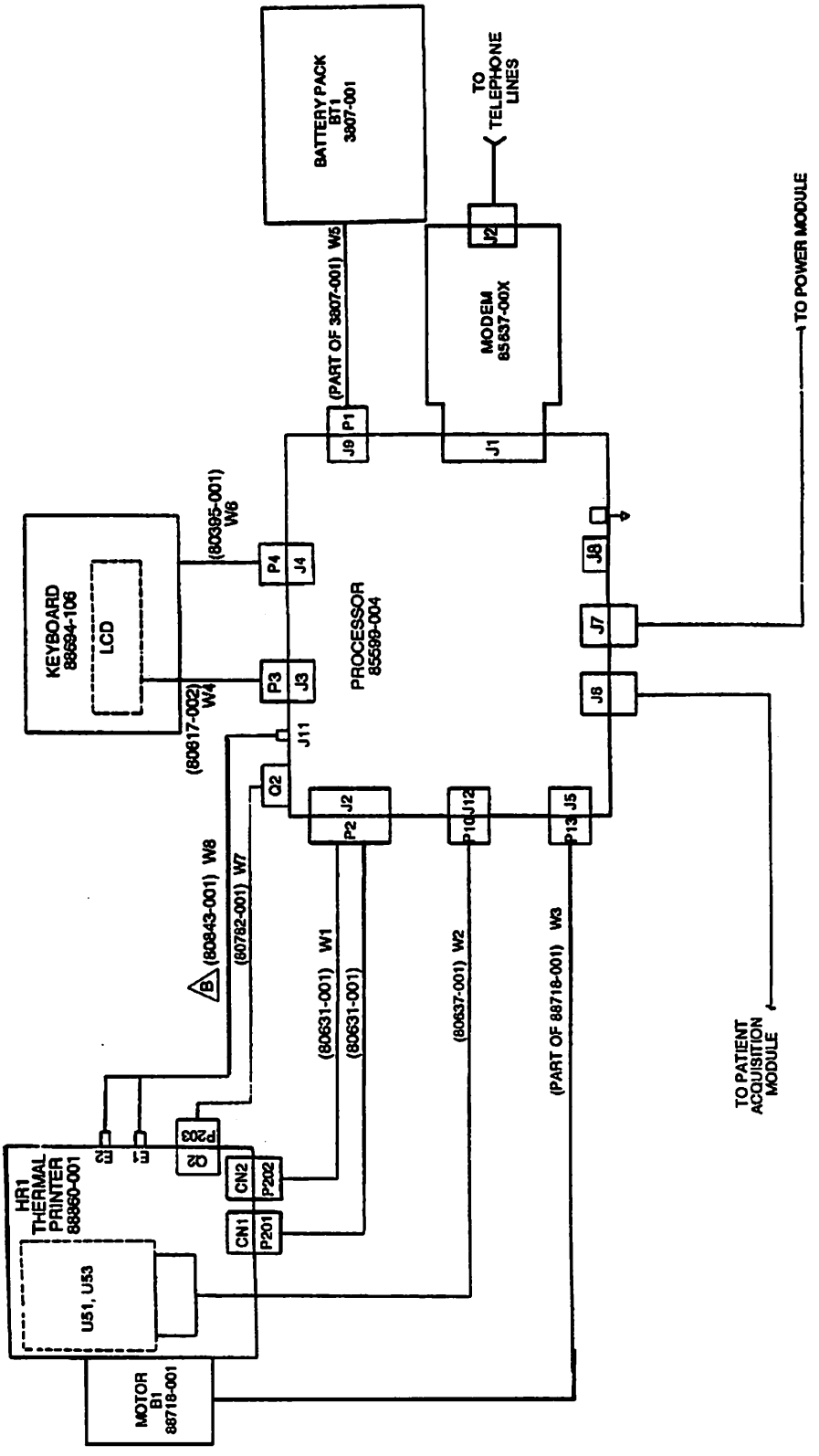
J1

NOTE:
1. ALL SIGNAL NAMES FOLLOWED BY AN ASTERISK (*) ARE ACTIVE LOW. (EXAMPLE: SIG*)

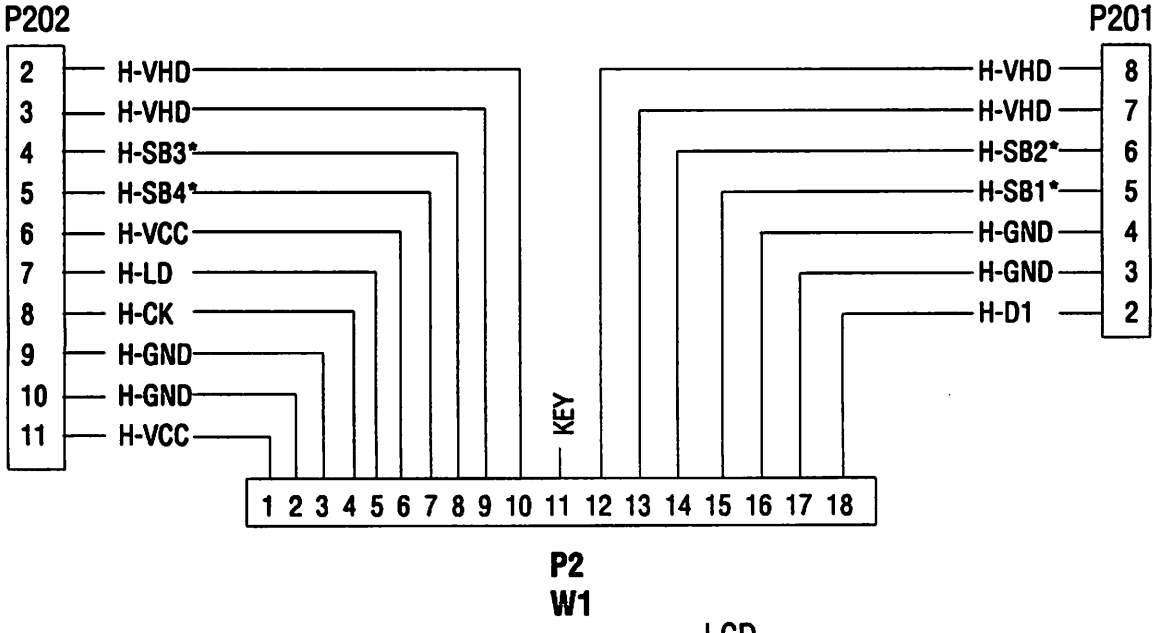
Modem MAC PC Schematic Revisions SD9591-002

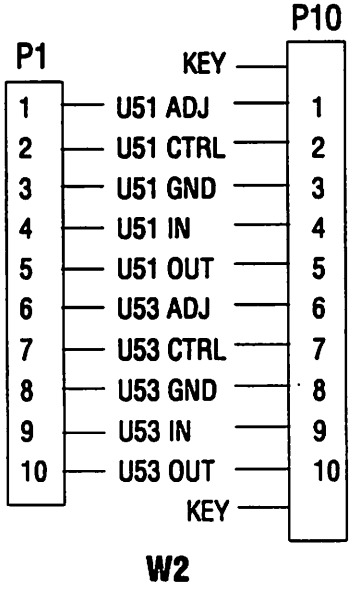
REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B				This revision corrected an error in the schematic for cable W8. W8 was shown as pn 80234-067. It is now correctly shown as pn 80843-001.

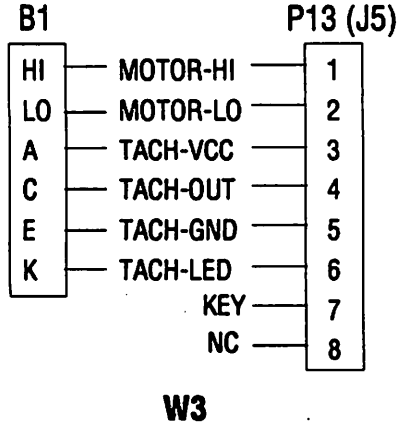
Modem MAC PC Schematic SD9591-002B

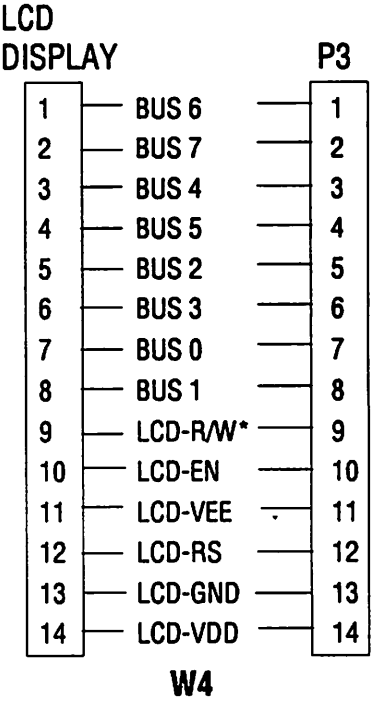


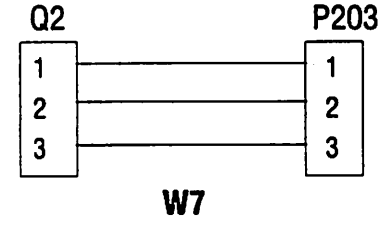
Modem MAC PC Schematic SD9591-002B



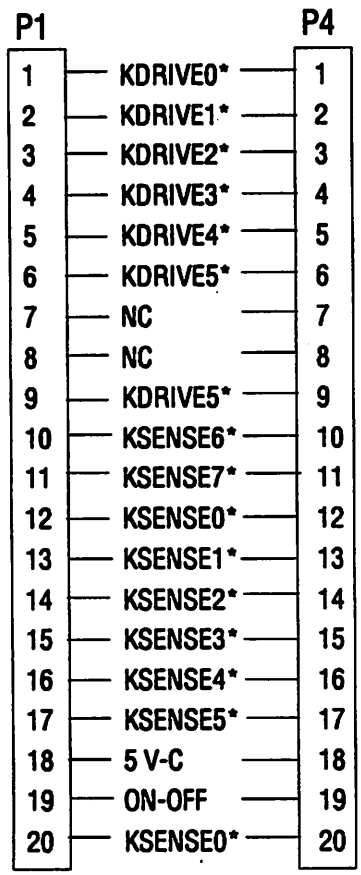




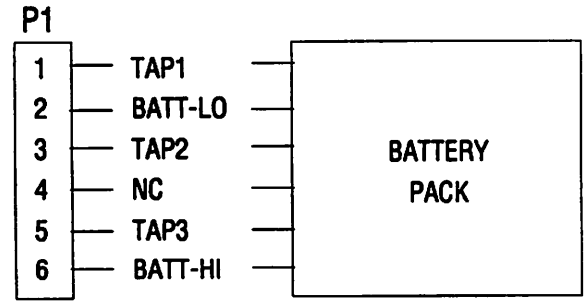




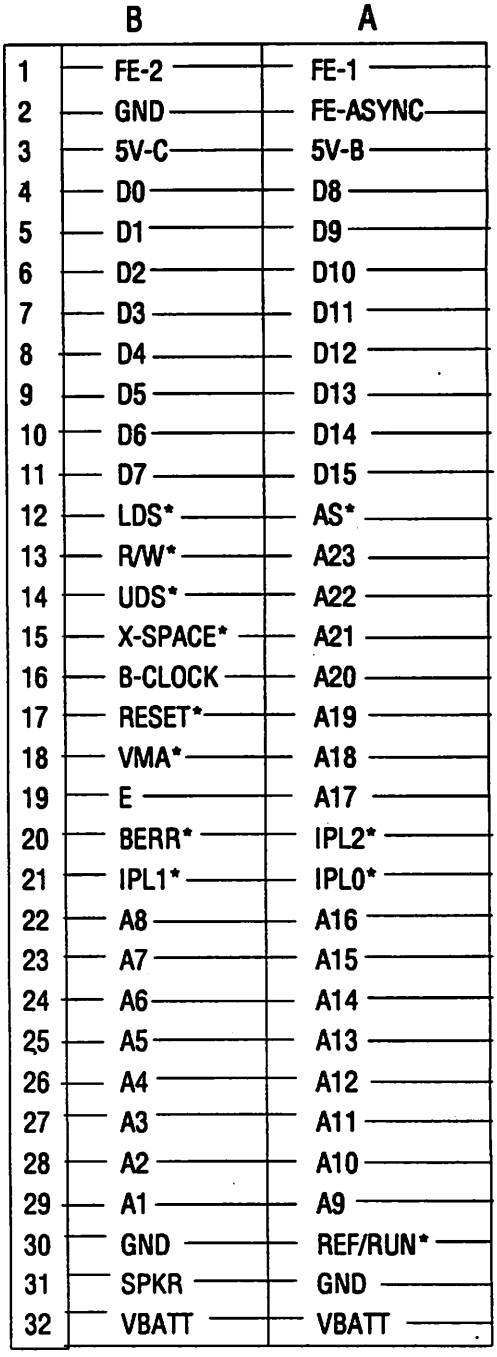
Modem MAC PC Schematic SD9591-002B



W6



W5



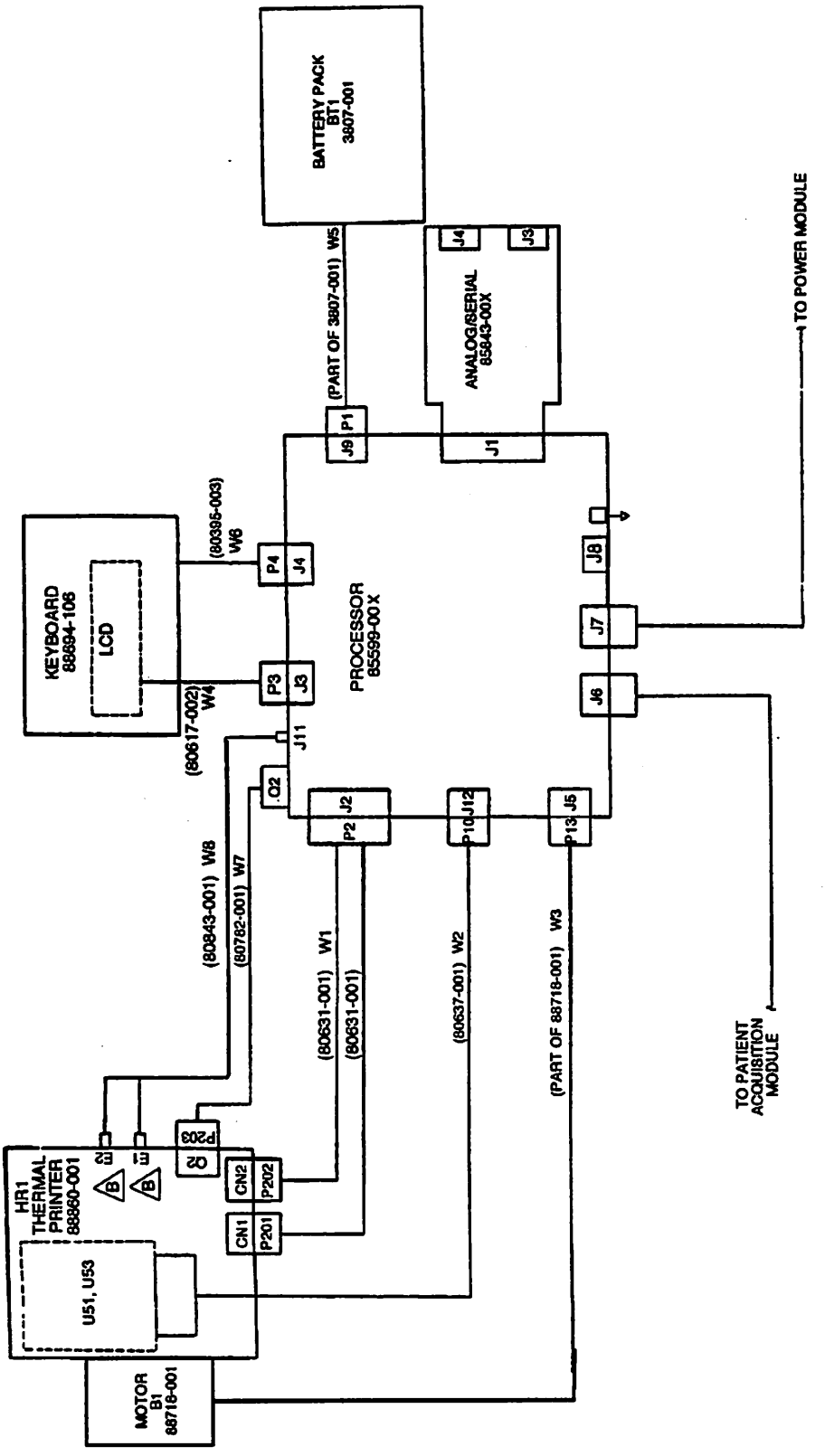
J1

NOTE:
1. ALL SIGNAL NAMES FOLLOWED BY AN ASTERISK (*) ARE ACTIVE LOW. (EXAMPLE: SIG*)

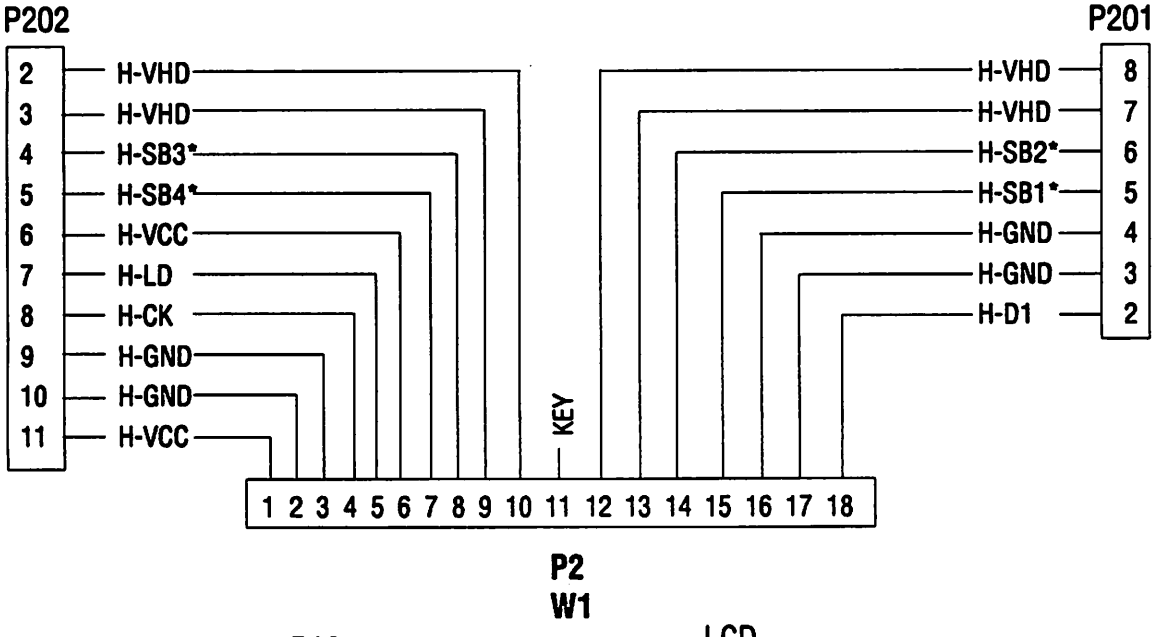
Analog/Serial MAC PC Schematic Revisions SD9591-003

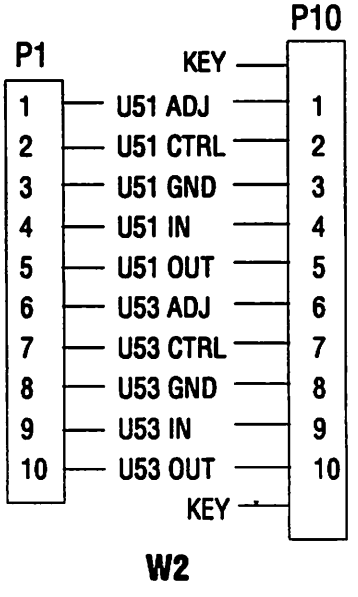
REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial release of this assembly.
B				This revision corrected an error in the schematic for cable W8. W8 was shown as pn 80234-067 and was drawn incorrectly. It is now correctly drawn and shown as pn 80843-001.

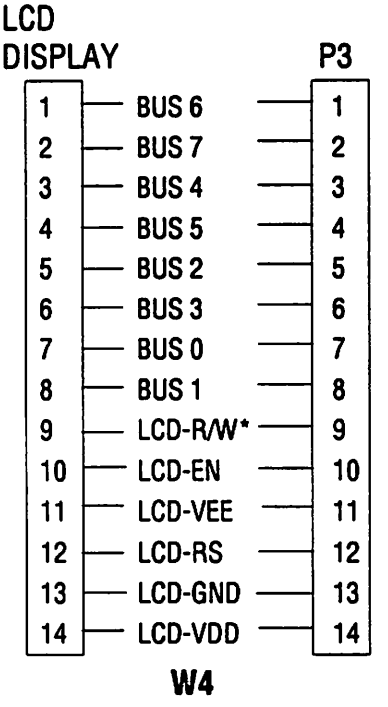
Analog/Serial MAC PC Schematic SD9591-003B

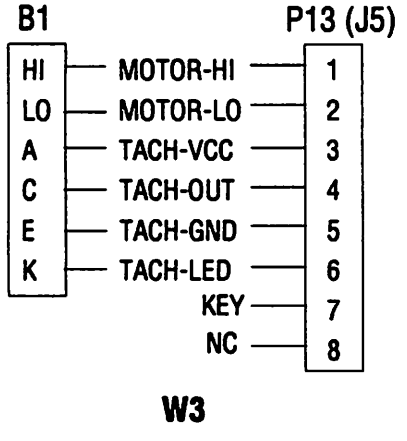


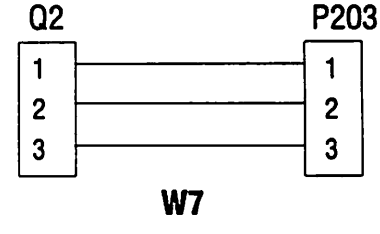
Analog/Serial MAC PC Schematic SD9591-003B



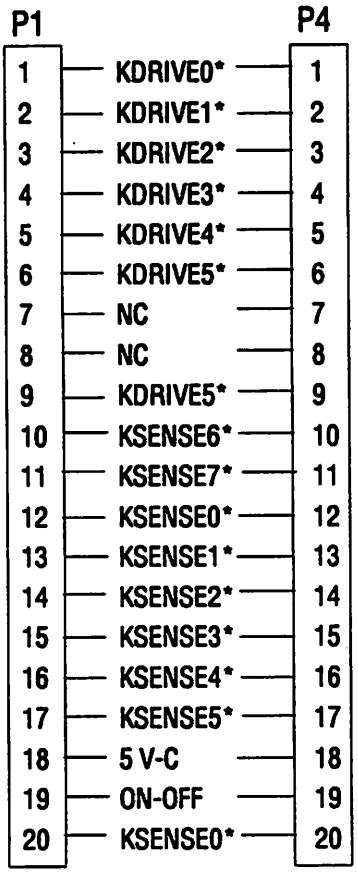




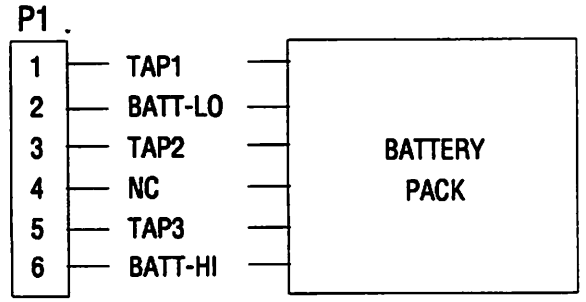




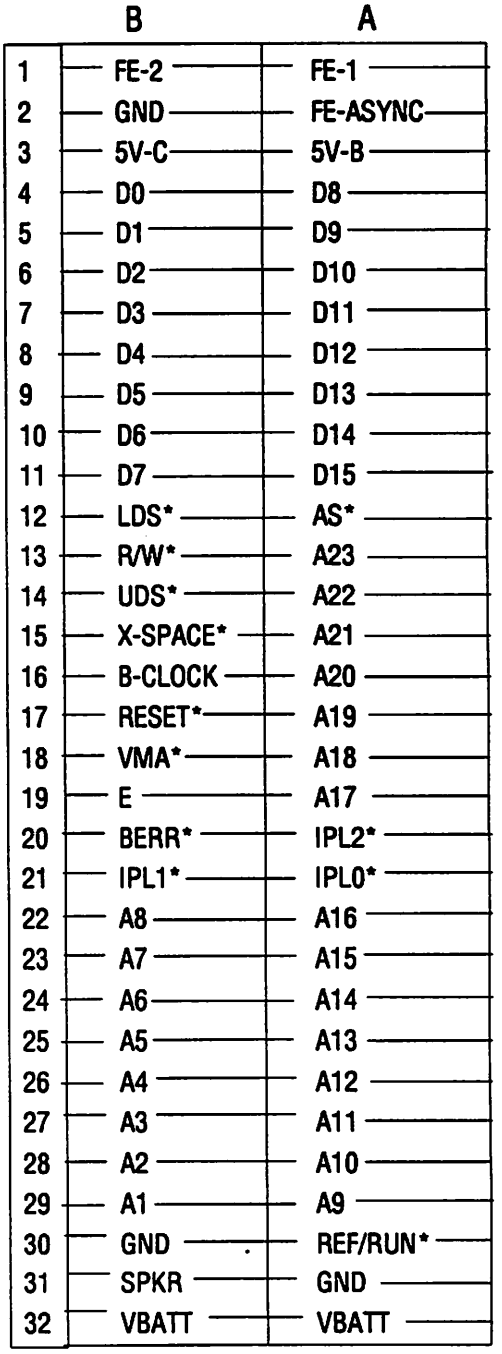
Analog/Serial MAC PC Schematic SD9591-003B



W6



W5



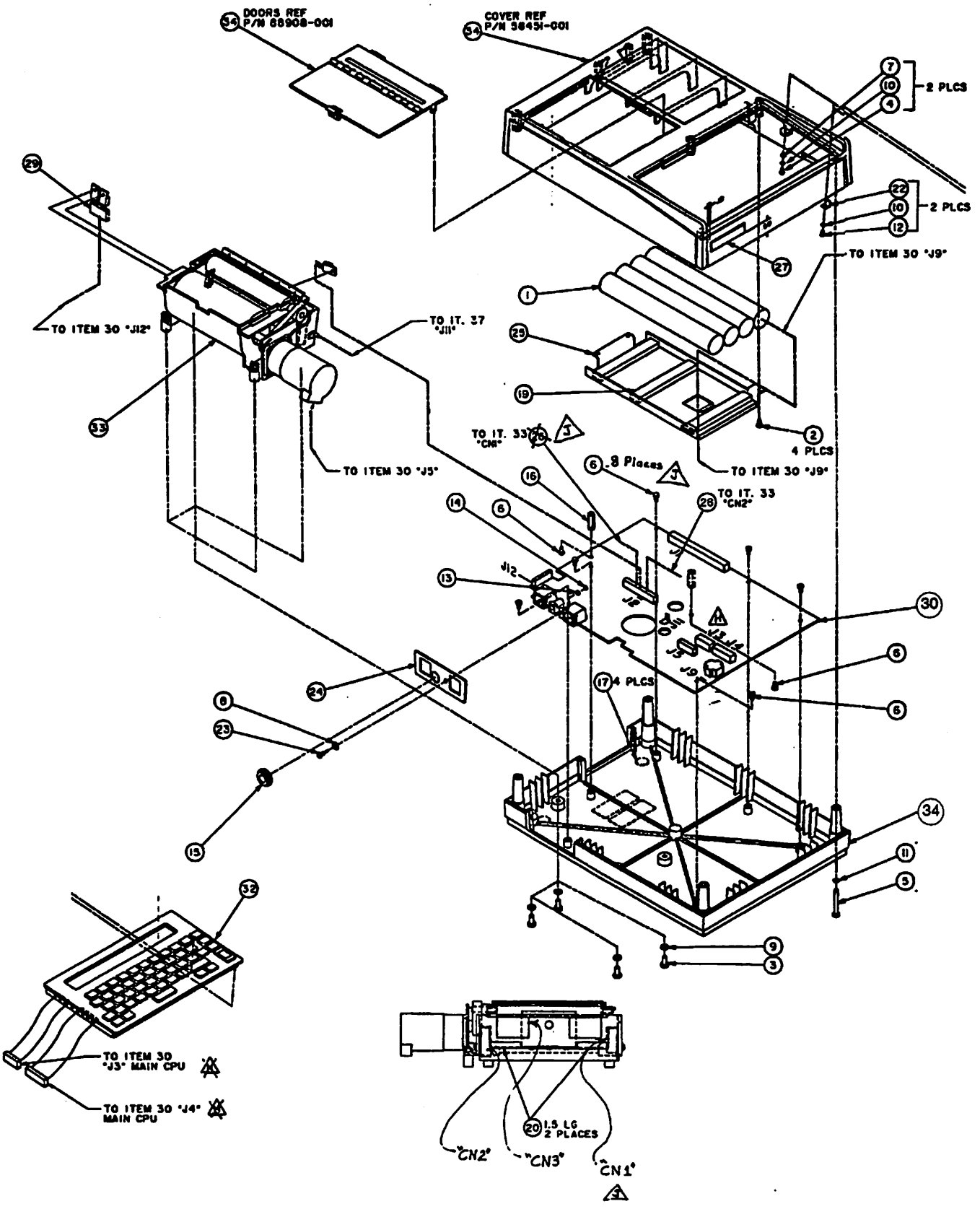
J1

NOTE:
1. ALL SIGNAL NAMES FOLLOWED BY AN ASTERISK (*) ARE ACTIVE LOW. (EXAMPLE: SIG*)

MAC PC Generic Assembly Revisions — PN 88936-001

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B	5	4502-640	Changed to 4502-660	These screws were too short.
C	5	4502-660	Changed to 4502-652	The screws were too long.
D	6	45074-408	Changed quant from 10 to 8	
	18	4656-412	Delete item 18	
	21	4846-006	Delete item 21	
	26	58614-004	Delete item 26	
	31	85676-001	Delete item 31	
E	30	85599-004	Change to 85599-005	A new main cpu pcb assembly was introduced with this revision. The new main cpu pcb assembly provided additional memory capacity as well as some new IC chips were used.
F				This revision moved the cable that previously was attached to the main cpu pcb assembly, J3, now goes to the LCD current limit J1.
G				No information on this revision is available.
H	28	80631-001	Changed to 80631-002	This revision provided a new main cpu pcb assembly to deal with a static discharge problem.
	30	85599-005	Changed to 95599-006	
J				The connector locations of item 28 were not well defined, this revision showed the location on the drawing.

MAC PC Generic Assembly Drawing PN 88936-001J



MAC PC Generic Assembly Parts List — PN 88936-001J

FIGURE/ ITEM	REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	QTY
1		BATTERY PACK MAC PC	3807-001	1
2		SCREW SEMS PH 4-40X1/4	45000-404	4
3		SCREW SEMS PH 8-32X3/8	45000-806	4
4		SCREW PH 2-56X5/16	4502-210	2
5		SCR PH 6-32 X 1 5/8	4502-652	4
6		SCREW BDGH 4-40X1/4	45074-408	8
7		WASHER FLAT SS #2	4520-002	2
8		WASHER FLAT SS #4	4520-004	1
9		WASHER FLAT SS #8	4520-008	4
10		WASHER SPLIT RING #2	4520-102	4
11		WASHER SPLIT RING #6	4520-106	4
12		SCREW PH 2-56X1/4	4502-208	2
13		WASHER FLAT NYLON #2	4520-402	1
14		SNAPRING E.062SHFT	4551-501	1
15		GROMMET RUBBER .375X.625	4583-006	1
16		SPCR HEX F/F NYL 4-40 X .75L	46056-412	2
17		PAD RBR BUMP .5 OD	4616-001	4
19		TAPE VINYL .25X.38	4806-003	1
20		EDGING RUBBER 1/16PNL BLK	4845-101	-
22		CLIP KEYBOARD RETAINER	57822-001	2
23		SCREW MAC PC PCB GROUND MOUNT	58185-001	1
24		TRIM PLATE I/O PANEL MAC PC	58455-002	1
25		BATTERY COVER MAC PC	58484-001	1
27		NAME PLATE MARQUETTE LOGO	70317-001	1
28		HARN PRINT HD TO CPU BD	80631-002	1
29		HARN REGULATOR TO PRCSR BOARD	80637-002	1
30		PCB MAC PC CPU	85599-006	1
32		KEYBRD MAC PC W/DSPLY INTL	88694-106	1
33		WRITER ASSY-4IN THERMAL	88860-001	1
34		KIT MAC PC PLASTIC	88913-001	1

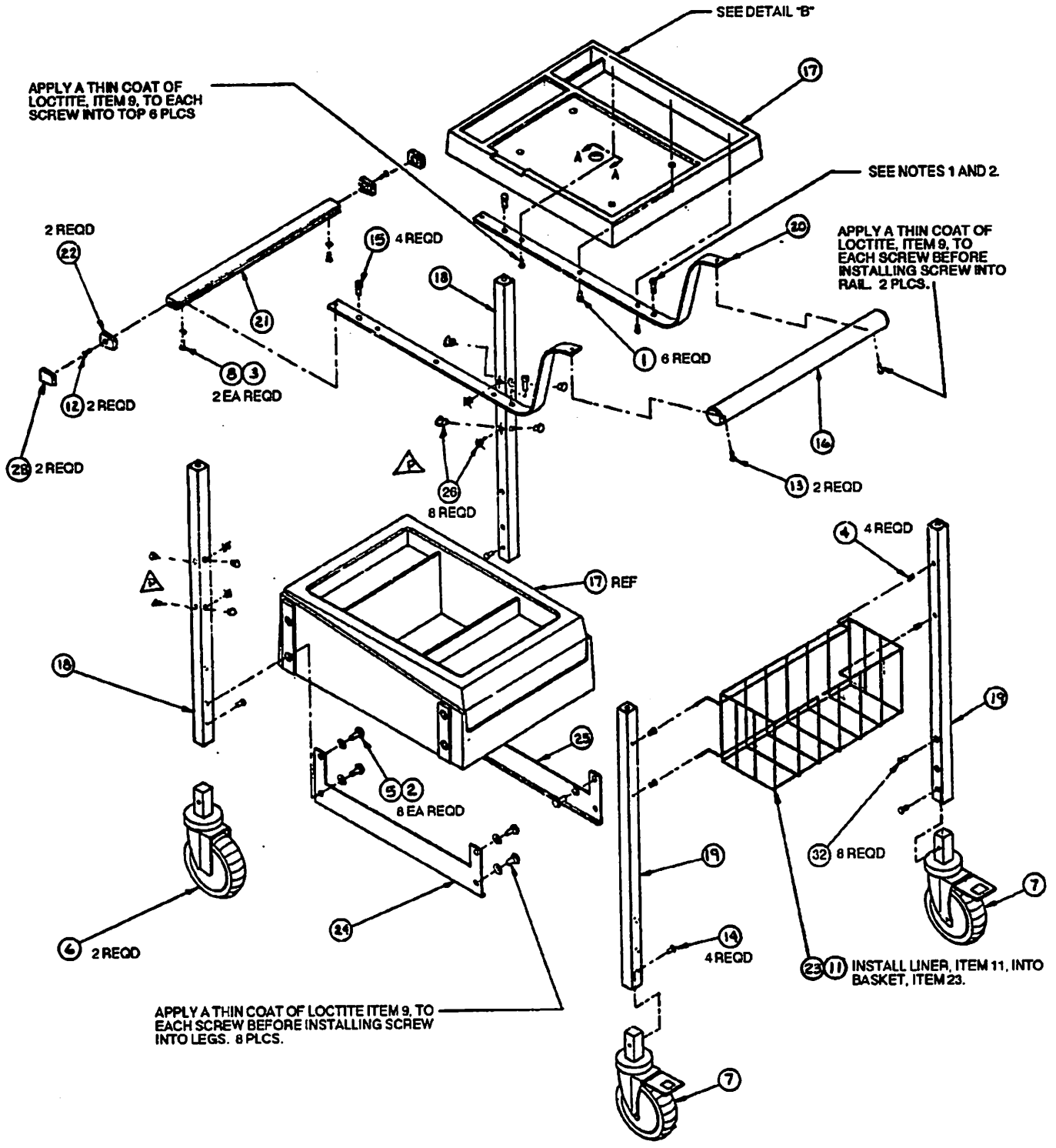
MAC PC Mobile Cart Assembly Revisions PN 9478-903

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B	28	70308-001	Delete item 28	
C	32	4522-212	Add, quant = 8	The legs were received from the vendor with finish in threads. The inserts are now being inserted into the legs at Marquette.
	33	4502-856	Add, quant = 4	
	34	4520-008	Add, quant = 4	
	35	9956-002	Add, quant = 1	
D	5	45002-216	Changed to 45031-210	This revision corrected the following problems: 1. A new screw needed for static protection.
	33	4502-856	Delete item 33	2. A shorter screw used to deal with inconsistent castors.
	34	4520-008	Delete item 34	
	35	9956-002	Delete item 35	3. Bumpers were added to protect crash bars and walls.
	14	45000-810	Changed to 45000-806	4. The color does not match between cart top and tray.
	28	58106-001	Changed to 58464-001	
	17	57757-001	Changed to 88966-001	
E				No information is available on this revision.
F	13	45040-112	Changed to 45018-908	The MAC PC cart's handle is being changed from wood to the same handle as other carts use.
	16	56855-001	Changed to 400381-002	
G	4	4580-312	Change quant from 8 to 4	
	26	4584-103	Add, quant = 4	
H	28	58464-001	Change quant from 1 to 2	
J	11	9263-003	Changed to 9263-004	There were 2 different types of basket liners. After this revision, there is only 1 type.

MAC PC Mobile Cart Assembly Revisions PN 9478-903

REV	ITEM	PART NUMBER	CHANGE	COMMENT
K	10	4851-053	Delete item 10	
	15	45031-210	Changed to 45011-211	
L	13	45018-908	Changed to 45040-112	This revision replaced the plastic handle with a wood handle.
	16	400381-002	Changed to 56855-002	
M	1	4640-810	Changed to 4640-808	The wrong screw was called out, this revision changed the part number to call out the correct screw.
N	33	9925-102	Add, quant = 1	Carton for shipping was not called out, this revision added the carton.
P	18	57758-001	Changed to 400500-001	
	26	4584-103	Changed quant from 4 to 8	

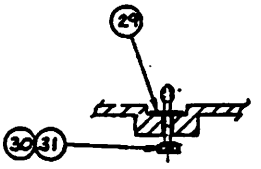
MAC PC Mobile Cart Assembly PN 9478-903P



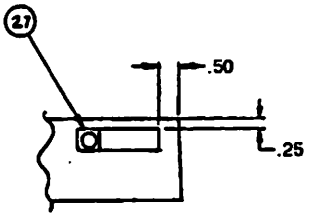
MAC PC Mobile Cart Assembly PN 9478-903P

NOTES:

1. UPSET THREADS OF IT. 15 SCREW PER MEI TOOL MT 2542-001 4 PLCS.
2. TORQUE ITEM 15 SCREW TO 12 FT-LBS.



SECTION 'A-A'



DETAIL 'B'

MAC PC Mobile Cart Assembly Parts List PN 9478-903P

FIGURE/ ITEM	REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	QTY
1		SCREW BLK W/WSHR 8-32 X 1/2	4640-808	6
2		WASHER LOCK EXTT 5/16	4520-312	8
3		WASHER LOCK SPLIT #10	4520-910	2
4		BUSHING HEYCO 312	4580-312	4
5		SCREW GR8 5/16-18X 1	45002-216	8
6		CASTER, SWIVEL	4702-007	2
7		CASTER FIXED	4702-006	2
8		SCREW PH 10-32X3/8	4752-912	2
9		CEMENT LOCITTE 242	4851-003	-
11		LINER MAC PC/S BASKET	9263-004	1
12		SCREW TT PH 6-32X3/8 BLK	45017-608	2
13		SCREW TTPH 10-32X3/4	45040-112	2
14		SCREW SEMS PH 8-32X3/8	45000-806	4
15		SCREW SKT 5/16-18 X 3/4 SS	45031-211	4
16		HANDLE WOOD WALNUT STAIN	56855-002	1
17		ASSY TRAY ACCESS MAC PC	88966-001	1
18		LEG CART REAR MAC/S	400500-001	2
19		LEG CART FRONT MAC PC	57758-002	2
20		RAIL HANDLES (PR) MAC PC CART	57760-003	1
21		CRASH BAR MAC 12 16L	57761-001	1
22		END CAP CRASH BAR MAC 12	57762-001	2
23		BASKET FRONT MAC 12	57766-001	1
24		BRACKET BASE SUPPORT LH MAC 12	57802-001	1
25		BRACKET BASE SUPPORT RH MAC 12	57802-002	1
26		PLUG HOLE DP-312	4584-103	8
27		NAME PLATE MARQUETTE LOGO	70317-001	1
28		RUBBER BUMPER GUARD	58464-001	2
29		RETAINER X WASHER .190ID	4551-205	1
30		WASHER BRASS 4970DX.255ID	45052-001	1
31		SCREW CPTV PNL 1/4-20 X 1.12	45125-136	1
32		INSERT BLIND THD 5/16-18 X72L	4522-212	8
33		CARTON BOX 4000/OPT-11 FOAM	9925-102	1

100 V, IEC PM-2 Power Supply Assembly Revisions PN 9518-201

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B	3	80629-001	Add, quant=1	
C				The note located by item 5 had a word chaged by this revision. The word "upper" was changed to the word "lower".
D	3	80629-001	Delete item 3	Foreign units were sent with wrong power plugs.
	11	80629-002	Add, quant=1	
	12	4535-001	Add, quant=1	
	13	4550-111	Add, quant=1	
E	3	80629-001	Add, quant=1	This revision repaired problems with the power cord.
	11	80629-002	Delete item 11	
F	12	9956-001	Add, quant=1	A storage bag was added for handling and packing.
G	12	9956-001	Delete item 12	The storage bag was uneeded.
H	9	70206-001	Changed to 404525-001	A new label was introduced by this revision.

120 V, IEC PM-2 Power Supply Assembly Revisions PN 9518-202

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B	3	80629-001	Add, quant=1	
C				This revision cleaned up a drawing error.
D	3	80629-001	Delete item 3	Foreign units were sent with wrong power plugs.
	11	80629-002	Add, quant=1	
	12	4535-001	Add, quant=1	
	13	4550-111	Add, quant=1	
E	3	80629-001	Add, quant=1	This revision repaired problems with the power cord.
	11	80629-002	Delete item 11	
F	12	9956-001	Add, quant=1	A storage bag was added for handling and packing.
G	12	9956-001	Delete item 12	The storage bag was uneeded.
H	9	70206-001	Changed to 404525-001	A new label was introduced by this revision.

200 V, IEC PM-2 Power Supply Assembly Revisions PN 9518-203

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B	3	80629-001	Add, quant=1	
C				This revision cleaned up a drawing error.
D	3	80629-001	Delete item 3	Foreign units were sent with wrong power plugs.
	11	80629-002	Add, quant=1	
	12	4535-001	Add, quant=1	
	13	4550-111	Add, quant=1	
E				This revision repaired problems with the power cord.
F	12	9956-001	Add, quant=1	A storage bag was added for handling and packing.
G	12	9956-001	Delete item 12	The storage bag was uneeded.
H	9	70206-001	Changed to 404525-001	A new label was introduced by this revision.

220 V, IEC PM-2 Power Supply Assembly Revisions PN 9518-204

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B	3	80629-001	Add, quant=1	
C				This revision cleaned up a drawing error.
D	3	80629-001	Delete item 3	Foreign units were sent with wrong power plugs.
	11	80629-002	Add, quant=1	
	12	4535-001	Add, quant=1	
	13	4550-111	Add, quant=1	
E				This revision repaired problems with the power cord.
F	12	9956-001	Add, quant=1	A storage bag was added for handling and packing.
G	12	9956-001	Delete item 12	The storage bag was uneeded.
H	9	70206-001	Changed to 404525-001	A new label was introduced by this revision.

240 V, IEC PM-2 Power Supply Assembly Revisions PN 9518-205

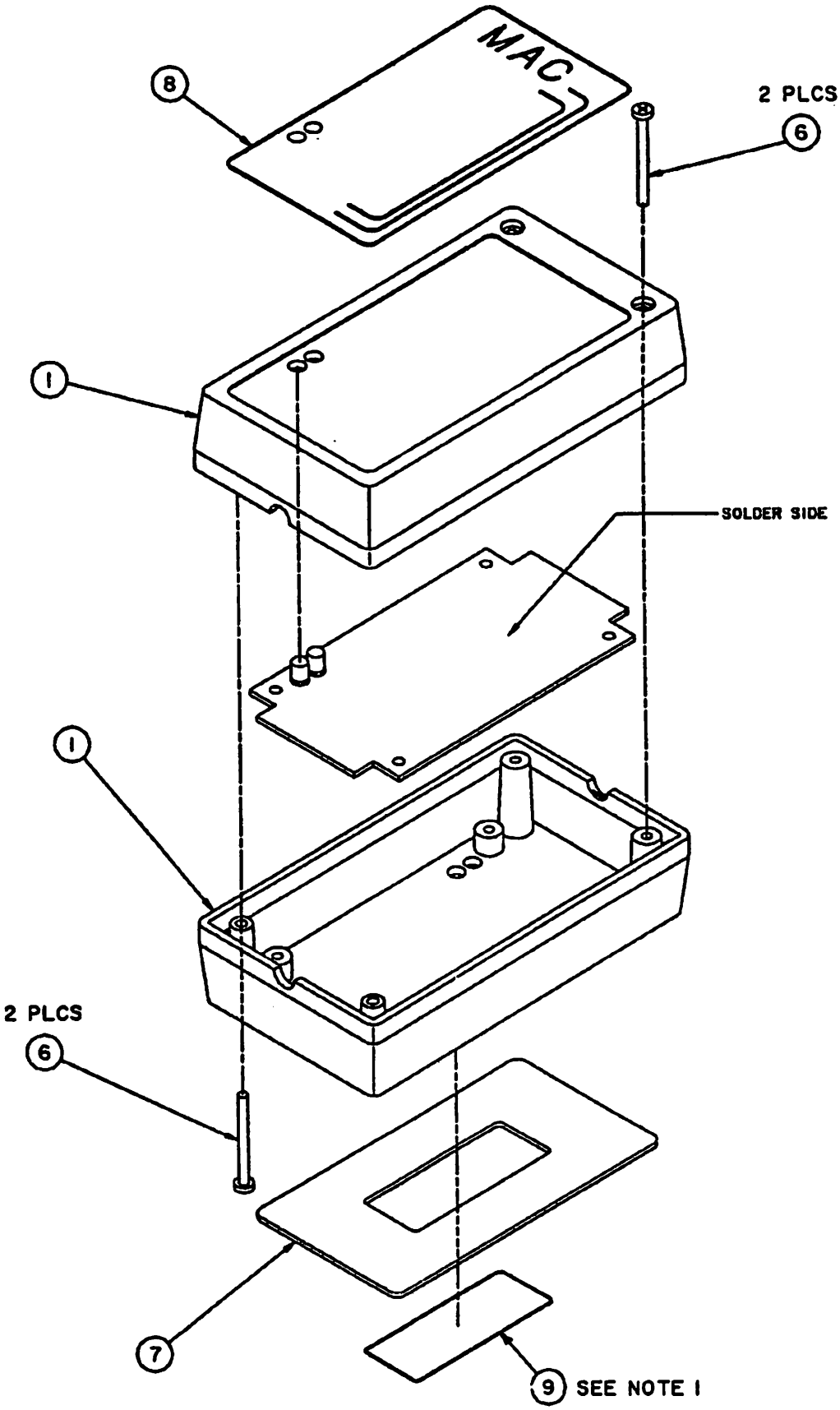
REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B	3	80629-001	Add, quant=1	
C				This revision cleaned up a drawing error.
D	3	80629-001	Delete item 3	Foreign units were sent with wrong power plugs.
	11	80629-002	Add, quant=1	
	12	4535-001	Add, quant=1	
	13	4550-111	Add, quant=1	
E				This revision repaired problems with the power cord.
F	12	9956-001	Add, quant=1	A storage bag was added for handling and packing.
G	12	9956-001	Delete item 12	The storage bag was uneeded.
H	9	70206-001	Changed to 404525-001	A new label was introduced by this revision.

120 V, UL PM-2 Power Supply Assembly Revisions PN 9518-206

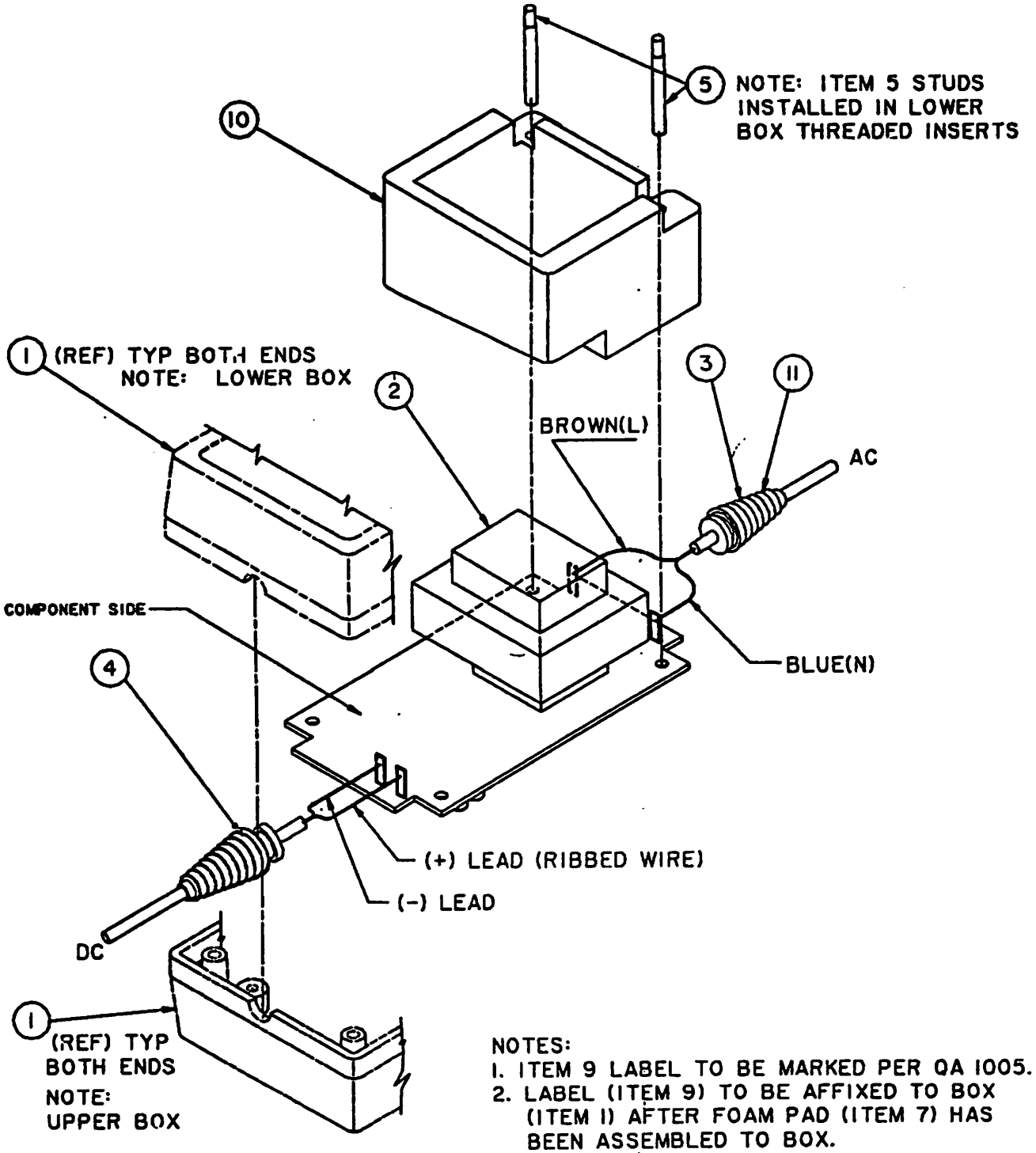
REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B	3	80629-001	Add, quant=1	
C				This revision cleaned up a drawing error.
D	12	9956-001	Add, quant=1	A storage bag was added for handling and packing.
E	12	9956-001	Delete item 12	The storage bag was uneeded.
F	9	70206-001	Changed to 404525-001	A new label was introduced by this revision.

NOTES

PM-2 Power Supply Assembly PN 9518-2XXH



PM-2 Power Supply Assembly PN 9518-2XXH



NOTES:
1. ITEM 9 LABEL TO BE MARKED PER QA 1005.
2. LABEL (ITEM 9) TO BE AFFIXED TO BOX (ITEM 1) AFTER FOAM PAD (ITEM 7) HAS BEEN ASSEMBLED TO BOX.

SEE CHART							QUAN	ITEM	← ASSEMBLY REVISION / ← ASSEMBLY VARIATIONS / LIST OF MATERIAL — PART NUMBER	DESCRIPTION	COMPONENT DESIGNATION
206	205	204	203	202	201						
2	2	2	2	2	2			1	57857-002	BOX BATTERY CHARGER	
								2			
					1			2	85626-102	PCB PWR SPLY MAC PC 100V	
1				1				2	85626-101	PCB PWR SPLY MAC PC 120V	
			1					2	85626-103	PCB PWR SPLY MAC PC 200V	
		1						2	85626-104	PCB PWR SPLY MAC PC 220V	
	1							2	85626-105	PCB PWR SPLY MAC PC 240V	
1				1	1			3	80629-001	CABLE POWER SUPPLY AC MAC PC UL/CSA	
								3			
								3			
								3			
1	1	1	1	1	1			4	80630-001	CABLE POWER SUPPLY DC MAC PC	
2	2	2	2	2	2			5	58164-001	STUD POWER SUPPLY: MAC PC	
4	4	4	4	4	4			6	45022-420	SCREW PNH 4-40X1 1/4 GRAY	
1	1	1	1	1	1			7	57858-001	PAD FOAM BATTERY CHARGER	
								8			
					1			8	70270-019	LABEL CHARGER BOX 100 V IEC 50-60HZ	
				1				8	70270-020	LABEL CHARGER BOX 120 V IEC 50-60HZ	
			1					8	70270-021	LABEL CHARGER BOX 200 V IEC 50-60HZ	
		1						8	70270-022	LABEL CHARGER BOX 220 V IEC 50HZ	
	1							8	70270-023	LABEL CHARGER BOX 240 V IEC 50-60HZ	
1								8	70270-018	LABEL CHARGER BOX 120 V UL/CSA 50-60HZ	
1	1	1	1	1	1			9	404525-001	LABEL BLANK 2X3/4	
1	1	1	1	1	1			10	58163-001	SHOCK BLOCK POWER SUPPLY MAC PC	
	1	1	1					11	80629-002	CABLE PWR SUPPLY AC MAC PC EURO	
								12			

(H)

ASSY #	REV	ECO#	DESCRIPTION
9518-201	H	18068	100 VOLTS IEC
9518-202	H	18068	120 VOLTS IEC
9518-203	H	18068	200 VOLTS IEC
9518-204	H	18068	220 VOLTS IEC
9518-205	H	18068	240 VOLTS IEC
9518-206	F	18068	120 VOLTS UL

120 V PM-3 Power Supply Assembly Revisions PN 9577-001

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B				No information available on this revision.
C	19	9983-006	Changed to 9983-008	The wrong shipping box was called out.
D	23	4502-856	Add, quant=4	Mounting screws are needed for mounting PM-3 to cart.
	24	4520-008	Add, quant=4	
	25	9956-002	Add, quant=1	
E				A Condor power supply replaced the Power One version of the power supply. The drawing was changed to reflect this change.
F	31	70206-002	Add, quant=1	Additional labeling was needed for UL.
G	32	402634-001	Add, quant=1	UL required instructions for use, they were added to the drawing.
H	8	80274-101	Delete item 8	The PM-3 power cords were moved to the MACPC-OMAR drawing.
	18	70175-001	Delete item 18	
J	4	70206-001	Changed to 404525-001, quant=2	A new product identification label was added to drawing.
	31	70206-001	Delete item 31	
K	18	99014-001	Add, quant=1	This revision corrected labels, added shipping materials, and corrected some notes.
	19	9983-008	Changed to 9928-200	

220 V PM-3 Power Supply Assembly Revisions PN 9577-002

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B				No information available on this revision.
C	19	9983-006	Changed to 9983-008	The wrong shipping box was called out.
D	17	70402-001	Changed to 70402-005	Voltage label said "50/60 Hz" which is not acceptable in some foreign countries. A new label was made that said "50 Hz only" and "400 mA" instead of ".4 A".
E	23	4502-856	Add, quant=4	Mounting screws are needed for mounting PM-3 to cart.
	24	4520-008	Add, quant=4	
	25	9956-002	Add, quant=1	
F				A Condor power supply replaced the Power One version of the power supply. The drawing was changed to reflect this change.
G	1	88850-001	Delete item 1	A new chassis was used for this version of the PM-3.
	30	88850-003	Add, quant=1	
H	8	80274-101	Delete item 8	The PM-3 power cords were moved to the MACPC-OMAR drawing.
J	4	70206-001	Changed to 404525-001, quant=1	A new product identification label was added to drawing.
K	4	404525-001	Change quant from 1 to 2	A label was added to the drawing.
L	18	99014-001	Add, quant=1	This revision corrected labels, added shipping materials, and corrected some notes.
	19	9983-008	Changed to 9928-200	
M	4	404525-001	Change quant from 2 to 1	The PM-3 German icon label has been given a part number to meet regulatory affairs requirements.
	33	404672-001	Add, quant=1	

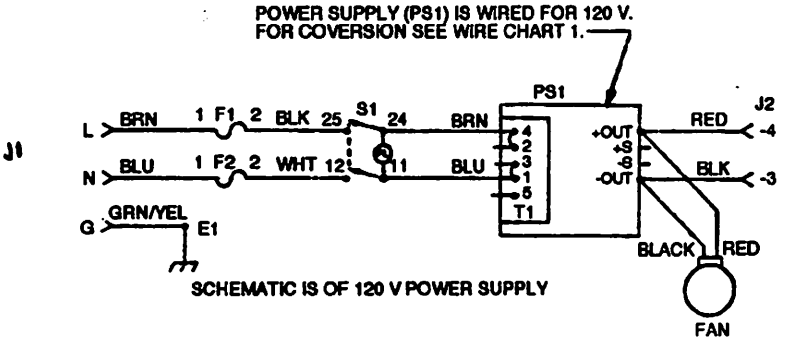
240 V PM-3 Power Supply Assembly Revisions PN 9577-003

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B	19	9983-006	Changed to 9983-008	The wrong shipping box was called out.
C	23	4502-856	Add, quant=4	Mounting screws are needed for mounting PM-3 to cart.
	24	4520-008	Add, quant=4	
	25	9956-002	Add, quant=1	
D	1	88850-001	Delete item 1	A new version of the 240 V PM-3 was created by this revision. It includes a fuse holder pcb mounted to the secondary of the transformer. The 88850-001 harness was rerouted to avoid contact with the potentially high temperature components of the PM-3 power supply.
	9	1910-012	Delete item 9	
	26	401185-001	Add, quant=2	
	27	1908-050	Add, quant=2	
	28	88850-002	Add, quant=1	
E	29	401861-001	Add, quant=1	The British need a label for the "power" switch.
F	8	80274-101	Delete item 8	The PM-3 power cords were moved to the MACPC-OMAR drawing.
G	4	70206-001	Changed to 404525-001, quant=1	A new product identification label was added to drawing.
H	4	404525-001	Change quant from 1 to 2	A label was added to the drawing.
J	18	99014-001	Add, quant=1	This revision corrected labels, added shipping materials, and corrected some notes.
	19	9983-008	Changed to 9928-200	
K	4	404525-001	Change quant from 2 to 1	The PM-3 German icon label has been given a part number to meet regulatory affairs requirements.
	33	404672-001	Add, quant=1	

100 V PM-3 Power Supply Assembly Revisions PN 9577-004

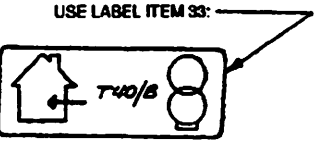
REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B	19	9983-006	Changed to 9983-008	The wrong shipping box was called out.
C	23	4502-856	Add, quant=4	Mounting screws are needed for mounting PM-3 to cart.
	24	4520-008	Add, quant=4	
	25	9956-002	Add, quant=1	
D				A Condor power supply replaced the Power One version of the power supply. The drawing was changed to reflect this change.
E	1	88850-001	Delete item 1	A new chassis was used for this version of the PM-3.
	30	88850-003	Add, quant=1	
F	8	80274-101	Delete item 8	The PM-3 power cords were moved to the MACPC-OMAR drawing.
G	4	70206-001	Changed to 404525-001, quant=1	A new product identification label was added to drawing.
H	4	404525-001	Change quant from 1 to 2	A label was added to the drawing.
J	18	99014-001	Add, quant=1	This revision corrected labels, added shipping materials, and corrected some notes.
	19	9983-008	Changed to 9928-200	
K	4	404525-001	Change quant from 2 to 1	The PM-3 German icon label has been given a part number to meet regulatory affairs requirements.
	33	404672-001	Add, quant=1	

PM-3 Power Supply Assembly — PN 9577-00XS



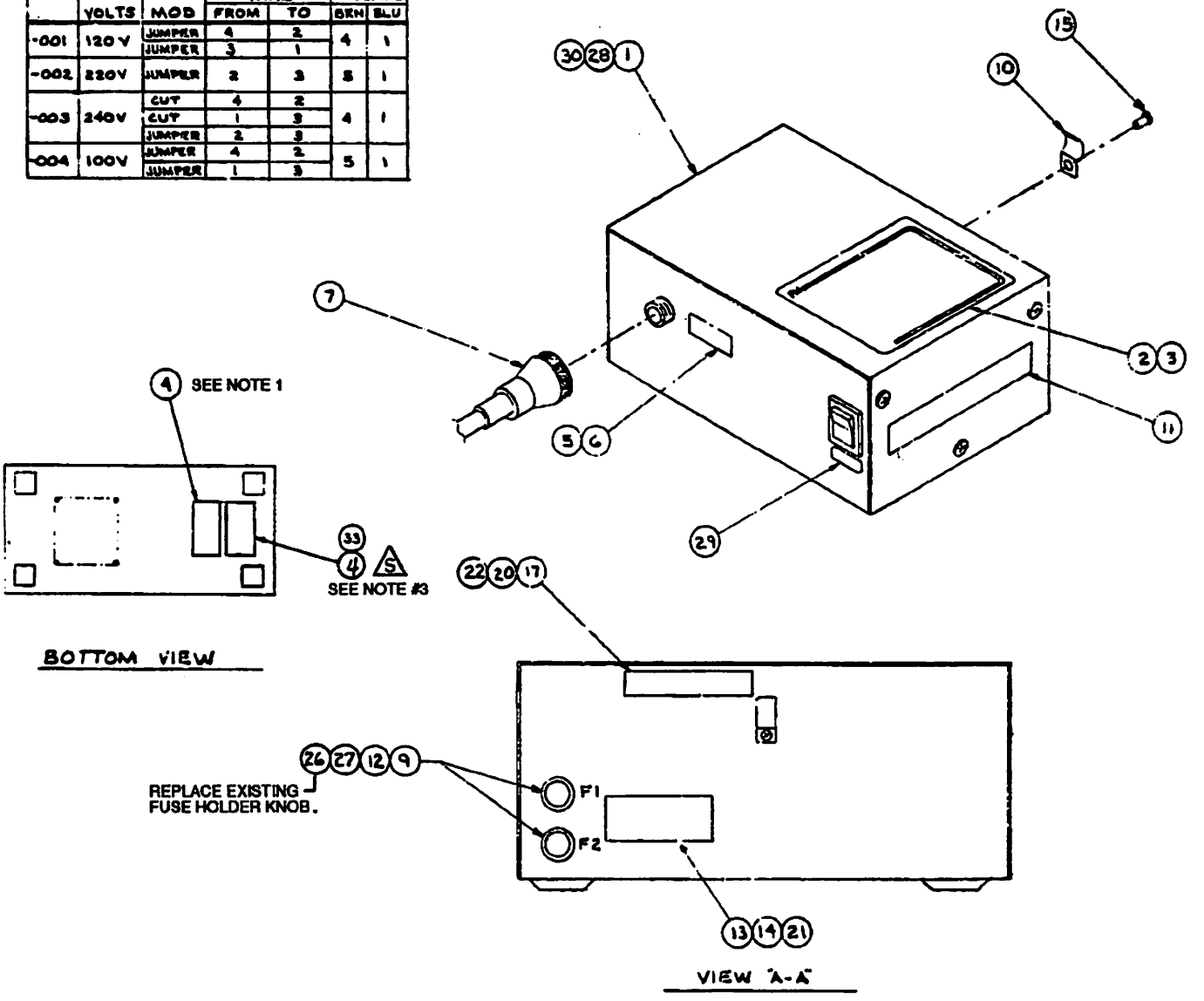
NOTE

1. MARK I ARF1 , ITEM 4
   SERIES: PM-3
   S/N: TO BE DETERMINED
2. PLACE SCREWS (ITEM 23), WASHERS (ITEM 24), AND DC PLUG (ITEM 7) INTO BAG (ITEM 25). PLACE BAG (ITEM 25) AND PM-3 INTO PLASTIC BAG (ITEM 16).
3. FOR -001, MARK LABEL, ITEM 4; ACCESSORY FOR USE WITH MAC PC.
   FOR -002, -003, -004 USE LABEL ITEM 33:



WIRE CHART 1

	VOLTS	MOD	WIRE FROM	WIRE TO	APPLY AC BRN	APPLY AC BLU
-001	120 V	JUMPER	4	2	4	1
		JUMPER	3	1		
-002	220V	JUMPER	2	3	3	1
-003	240V	CUT	4	2	4	1
		CUT	1	3		
		JUMPER	2	3		
-004	100V	JUMPER	4	2	5	1
		JUMPER	1	3		



PM-3 Power Supply Assembly Parts List — PN 9577-00XS

Item #	Desig.	Description	Part Number	Assembly Variation			
				-001	-002	-003	-004
1		MAC PC PM-3 Chassis	88850-001	1			
2		PM-3 Power Supply Label	70389-001	1			
3		Internal PM-3 Power Supply Label	70389-003		1	1	1
4		2 x 3/4 Balnk Label	404525-001	2	1	1	1
5		IEC PM-3 1 A/28 VDC Output Label	70391-002		1	1	1
6		MAC PC Power Supply Output Label	70391-002	1			
7		6 Ft Power Supply DC Plug Harness	80746-001	1	1	1	1
9	F1, F2	3 AG 1/2 A SB Fuse	1910-012		2		
10		Cush- .31 ID Cable Clamp	4528-106	1	1	1	1
11		Explosion Hazard Danger Label	70157-002	1			
12	F1, F2	3 AG 1 A SB Fuse	1910-100				2
13		Fuse Warning Label	70124-001	1			
14		0.5 A SB 250 V IEC Fuse Label	70120-101		1	1	
15		6-32 x 3/8 Blk w/Washer Screw	4640-606	1	1	1	1
17		400 mA/220 V Input IEC PM-3 Label	70402-005		1		
18	Not Shown	18 x 20 Poly Anti-static Bag	99014-001	1	1	1	1
19	Not Shown	Shipping Carton	9928-200	1	1	1	1
20		400 mA/240 V IEC PM-3 Input Label	70402-002			1	
21		1.0 A IEC Fuse Label	70120-102				1
22		1.0 A/100 V IEC PM-3 Input Label	70402-003				1
23		PH 8-32 x 1 3/4 Screw	4502-856	4	4	4	4
24		SS #8 Flat Washer	4520-008	4	4	4	4
25		4 x 6 2 Mil Zip-Lock Storage Bag	9956-002	1	1	1	1
26		5 x 20 HLDR Fuse Knob	401185-001			2	
27		Slo-Blo 500 mA Metric Fuse	1908-050			2	
28		PM-3 Chassis w/Fuse Bd Assembly	88850-002			1	
29		British Power Label	401861-001			1	
30		MAC PC PM-3 Chassis Assembly	88850-003		1		1
32	Not Shown	PM-3 Instruction Sheet	402634-001	1			
33		German PM-3 Icon Label	404672-001		1	1	1

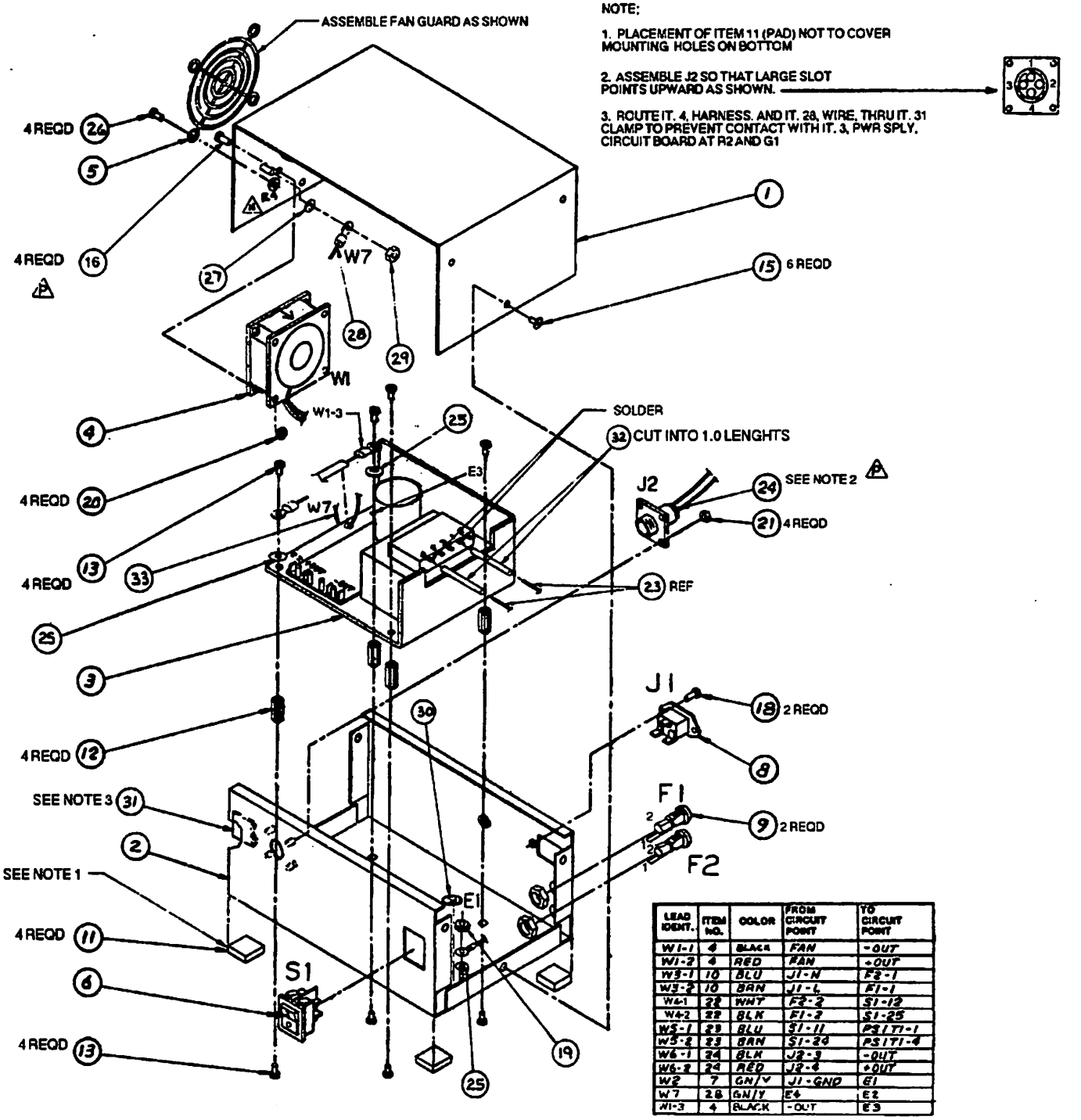
MAC PC PM-3 Chassis Assembly Revisions PN 88850-001

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B	16	45074-412	Add, quant=4	The studs were too short, the nuts were hard to put on.
	17	4851-003	Add item	
	20	4521-704	Change quant from 8 to 4	
	21	4521-104	Add, quant=4	
	25	4520-806	Add, quant=1	
C				This revision added detail of the fan guard, item 5, noting how to orient the guard onto the cover during assembly.
D				No information is available on this revision.
E				No information is available on this revision.
E1				A general drawing update was performed.
F				This revision changed the installation of the DAC line fuse holders so that the long tab (Tab 1) is on the bottom. Also, the power switch is now shown so that position "I" is up and position "0" is down.
G	4	80749-001	Changed to 80749-002	The fan wire harness was modified to reduce arching between chassis ground and DC output ground during hi-pot tests. Bidirectional 200 V transorbs were added to the harness assembly.
G1				A general drawing update was performed.
H	25	4520-806	Change quant from 1 to 2	A star washer was missing beneath W1-3 and W7.
J	30	70437-005	Add item	A label that calls out ground was added.
K	25	4520-806	Change quant from 2 to 3	A new 240 V PM-3 was released, this assembly was modified by this release.
	31	45100-100	Add, quant=1	

MAC PC PM-3 Chassis Assembly Revisions PN 88850-001

REV	ITEM	PART NUMBER	CHANGE	COMMENT
L	3	88853-001	Changed to 88853-004	The power supply vendor was changed from Power One to Condor.
	23	80740-001	Changed to 80740-002	
	32	4882-104	Add,quant=.17	
M				This revision added a stud for ground only to satisfy TUV requirements.
N	33	4535-001	Add, quant=1	Shrink tubing was added for TUV approval.
P	7	80307-001	Changed to 80307-034	Item 7 was too short and item 26 was too long. (See parts list and exploded view on following page.)
	26	45000-810	Changed to 45000-806	

MAC PC PM-3 Chassis Assembly — PN 88850-001P



LEAD IDENT.	ITEM NO.	COLOR	FROM CIRCUIT POINT	TO CIRCUIT POINT
W1-1	4	BLACK	FAN	-OUT
W1-2	4	RED	FAN	+OUT
W3-1	10	BLU	J1-N	F2-1
W3-2	10	BRN	J1-L	F1-1
W4-1	22	WHT	F2-2	S1-12
W4-2	22	BLK	F1-2	S1-25
W5-1	23	BLU	S1-11	PS1T1-1
W5-2	23	BRN	S1-24	PS1T1-4
W6-1	24	BLK	J2-3	-OUT
W6-2	24	RED	J2-4	+OUT
W2	7	GN/Y	J1-GND	E1
W7	28	GN/Y	E4	E2
W1-3	4	BLACK	-OUT	E3

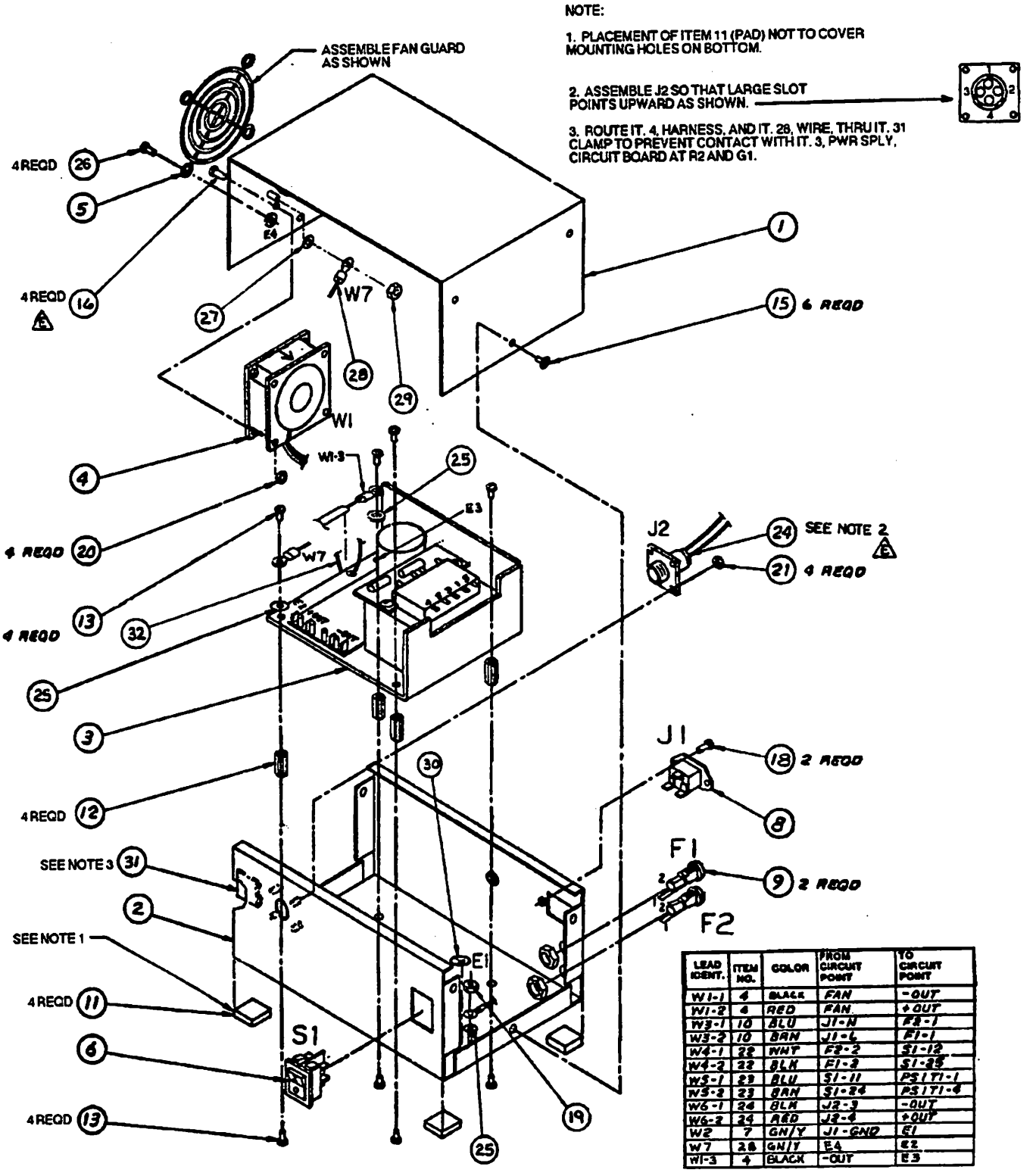
MAC PC PM-3 Chassis Assembly Part List PN 88850-001P

FIGURE/ ITEM	REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	QTY
1		COVER TOP PWR SPLY	58327-006	1
2		BASE PWR SPLY	58327-007	1
3		ASSY PM-3 MAC 6 POWER SUPPLY	88853-004	1
4		HARN FAN/PWR SUPPLY	80749-002	1
5		FINGER GUARD 2.81SQ MTNG HOLE	1465-912	1
6		SWITCH ROCKER DPST GREEN NEON	1642-101	1
7		WIRE 16 GA GN/Y 4.50L	80307-034	1
8		CONN INL 3M .25QC	1880-002	1
9		HLDR FUSE 3AG RT ANGLE 3/16QC	1740-008	2
10		HARN AC PWR INLET/FUSES	80559-002	1
11		PAD RBR BUMP .755Q	4616-002	4
12		SPACER 6-32 X 3/4	4603-612	4
13		SCREW SEMS PH 6-32X3/8	45000-606	8
15		SCREW BLK W/WSHR 6-32 X 3/8	4640-606	6
16		SCREW PNH 4-40X1 1/4 GRAY	45022-420	4
18		SCREW BLK PH 4-40 X 3/8	4641-406	2
19		NUT HEX KEPS 6-32	4521-706	1
20		NUT HEX KEPS 4-40	4521-704	4
21		NUT ESNA 4-40	4521-304	4
22		HARN PWR SWITCH/FUSES 5.50L	80560-002	1
23		HARN PWR SWITCH/PWR SUPPLY STP	80740-002	1
24		HARN DC CONN/PWR SUPPLY	80748-001	1
25		WASHER LOCK EXT/INT #6	4520-806	3
26		SCREW SEMS PH 8-32X3/8	45000-806	1
27		WASHER LOCK INTT #8	4520-208	1
28		WIRE 16GA GN/Y 7L	80307-015	1
29		NUT HEX KEPS 8-32	4521-708	1
30		LABEL SYMBOL GROUND	70437-005	1
31		CABLE CLAMP	45100-100	1
32		TUBING FIT-221 1/8 BLK	4882-104	-
33		TIE WRAP 4.00LG X .125W	4535-001	1

MAC PC PM-3
Chassis w/Fuse Board Assembly Revisions PN 88850-002

REV	ITEM	PART NUMBER	CHANGE	COMMENT
A				Initial revision of this assembly.
B				This revision added a stud for ground only to satisfy TUV requirements.
C	32	4535-001	Add, quant=1	Shrink tubing was added for TUV approval.
D	23	80740-001	Changed to 80740-002	Faston were removed because they do not fit on the power supply terminals. The harness ends are now soldered on to the power supply terminals.
E	7	80307-001	Changed to 80307-034	Item 7 was too short and item 26 was too long. (See parts list and exploded view on following page.)
	26	45000-810	Changed to 45000-806	

MAC PC PM-3 Chassis w/Fuse Board Assembly PN 88850-002E



LEAD IDENT.	ITEM NO.	COLOR	FROM CIRCUIT POINT	TO CIRCUIT POINT
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W1-2	4	RED	FAN	+OUT
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W4-1	22	WHT	F2-2	S1-12
W4-2	22	BLK	F1-2	S1-25
W5-1	23	BLU	S1-11	PS1T1-1
W5-2	23	BRN	S1-24	PS1T1-4
W6-1	24	BLK	J2-3	-OUT
W6-2	24	RED	J2-4	+OUT
W2	7	GN/Y	J1-GND	E1
W7	28	GN/Y	E4	E2
W1-3	4	BLACK	-OUT	E3

MAC PC PM-3
Chassis w/Fuse Board Assembly Parts List — PN 88850-002E

FIGURE/ ITEM	REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	QTY
1		COVER TOP PWR SPLY	58327-006	1
2		BASE PWR SPLY	58327-007	1
3		ASSY PM-3 MAC 6 POWER SUPPLY	88853-004	1
3		ASSY PM-3D PWR SPLY W/SEC FUSE	88853-003	1
4		HARN FAN/PWR SUPPLY	80749-002	1
5		FINGER GUARD 2.81SQ MTNG HOLE	1465-912	1
6		SWITCH ROCKER DPST GREEN NEON	1642-101	1
7		WIRE 16 GA GN/Y 4.50L	80307-034	1
8		CONN INL 3M .25QC	1880-002	1
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10		HARN AC PWR INLET/FUSES	80559-002	1
11		PAD RBR BUMP .755Q	4616-002	4
12		SPACER 6-32 X 3/4	4603-612	4
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28		WIRE 16GA GN/Y 7L	80307-015	1
29		NUT HEX KEPS 8-32	4521-708	1
30		LABEL SYMBOL GROUND	70437-005	1
31		CABLE CLAMP	45100-100	1
32		TUBING FIT-221 1/8 BLK	4882-104	-
33		TIE WRAP 4.00LG X .125W	4535-001	1

NOTES

Chapter 11
Tech Memo Summary

Tech Memo Summary

Introduction

Refer to the tech memo for detailed information.

Tech memos contain information for making improvements and carrying out modifications on Marquette products. This chapter summarizes the important tech memos relating to the MAC PC electrocardiograph. Refer to the original tech memo for more detailed information.

TY-709 **Noise in various leads even when using a simulator.**

On processor pcb assemblies, pn 85599-002, capacitor C30 and resistor R36 may not be the correct values and should be changed.

TG-744
3/25/87 **Writer speed increases during roller tests.**

The gain of transistor Q4, on the processor pcb assembly, varies so resistor R60 and resistor R68 are changed to reduce the effect.

TG-749
4/14/87 **Baseline artifact causing unacceptable traces.**

If the patient is too close to the MAC PC electrocardiograph, then radiated noise from the unit may be picked up.

TG-760
6/19/87 **High failures for 32-kHz crystals and insufficient current for 14-lead acquisition modules.**

Replace resistor R75 and resistor R23 on the processor pcb assembly.

TG-785
8/26/87 **Intermittent printing on thermal paper**

A problem during manufacturing of the thermal paper resulted in an uneven thermal coating on the thermal paper. Check the thermal paper before troubleshooting a MAC PC electrocardiograph for this problem.

TG-787
8/27/87 **False *Out of Paper* error message on units with the thermal print head, pn 1479-003.**

The amount of drag for the new thermal print head is different than the old ones. Therefore excessive current is required to advance the thermal paper and the software interprets this as an out of paper condition. The solution is to change the programmed value for the out of paper condition using the *Mot* utility. Later software already has this new data.

NOTE

A new tech memo format/numbering system was introduced in March, 1989.

Refer to the tech memo for detailed information.

DCARTS-001-4 3/22/89

Tip on cleaning thermal print head easily.

This memo provides a better way to clean the thermal print head. See the memo for more information.

DCARTS-010-3 7/27/89

***No Modem* error message or intermittent modem operation.**

Position of metal standoff below modem pcb assembly may be shorting base of Q1 on modem pcb assembly. Reposition the lead of Q1's base away from the standoff. Resolder Q1 so the base is not shorting to standoff.

DCARTS-015-4 8/15/89

Tips on preventing fading traces.

The many factors that affect long-term image retention on thermal paper are described. Attention should be paid to thermal print head pressure, position, voltage, and cleanliness.

DCARTS-016-4 8/24/89

New vendor for PM-3 power module.

The vendor for the power supply used in the PM-3 power module has been changed from Power One to Condor. (For details, refer to the paragraphs titled "PM-3 Power Supply Vendor Change" in chapter 5, Power Modules.)

DCARTS-019-3 9/25/89

Troubleshooting guide for the most frequent failures on the MAC PC electrocardiograph.

This memo has helpful summary information. (For additional information, refer to Parts Memo PM-009, dated 9/20/89.)

DCARTS-020-4 10/10/89

Thermal print head replacement in MAC PC electrocardiograph with writer 2 (L5).

When replacing a thermal print head in a MAC PC electrocardiograph with writer 2, order kit, pn 1479-KIT.

DCARTS-020A-4
2/7/90

Copper static brush is easily damaged.

Replace the copper finger-type static brush with soft brush. Preliminary versions of new pivot plate have 3 mounting holes. Do not install center screw since it would interfere with plunger screw.

DCARTS-021-4
10/16/89

Cart answers and then terminates call in reverse transmission (receive) from a MUSE system.

Check Cart Setup. The correct modem values are *Transmit Sync Time:* 148.3 ms and *Answer Tone Frequency:* 2025 Hz.

DCARTS-024-3
11/16/89

Cart will not answer the telephone in reverse transmit mode.

U36 may have been installed incorrectly on modem pcb assembly. The "E" and "+" connections should be towards CR9. (For details, refer to paragraphs titled "Problems in Reverse Transmission Mode" in chapter 9, Modem.)

DCARTS-029-3
2/9/90

Describes modifications to MAC PC electrocardiograph to prevent static-discharge damage to lcd and loss of setup data.

Two modifications are recommended: replace the lcd on all units and add a current-limiting pcb assembly. (For details, refer to the paragraphs titled "Static Discharge Problems" in chapter 4, General Troubleshooting.)

DCARTS-031-3
2/22/90

Random loss of setup and rebooting of unit usually associated with a loud squeal from speaker.

On the cpu pcb assembly, pn 85599-XXX, the wrong part was inserted in location U9. In suspect units, replace U9 with pn 3203-264.

DCARTS-034A-3
8/31/90

Appearance of false 'door open' or 'out-of-range' messages during calibration on MAC PC electrocardiographs with writer 2. Light printing may also occur.

Over time, the thermal print head pressure spring can weaken. To fix problem, install adjustable secondary pressure device. (For details, refer to the paragraphs titled "Writer 2 Adjustments" in chapter 8, Writer 2.)

DCARTS-038-3 5/31/90 **Announces release of 006/106 software for MAC PC electrocardiograph.**

Replaces earlier version software. (For details, refer to the paragraphs titled "Software/Hardware Configurations" in chapter 4, General Troubleshooting.)

DCARTS-050-3 2/15/91 **The modem standoffs are too long causing poor connection to the cpu.**

This memo called for the replacement of the current standoffs with slightly shorter ones. See Tech Memo for more information.

DCARTS-051-4 2/15/91 **A new vendor was chosen for the PM-3 and PM-4 power supply fan.**

When replacing one of these fans, use the part numbers and procedures provided by the Tech Memo.

DCARTS-053-3 5/31/91 **The lcd lens is easily scratched.**

When necessary, replace any scratched lenses with new coated ones. See Tech Memo for more information.

DCARTS-054-3 5/31/91 **This tech memo announced the release of 007B/107A for the MAC PC electrocardiograph.**

See Tech Memo for more information.

DCARTS-055-3 7/31/91 **Mylar cone speakers have a high failure rate.**

Replace defective speakers with paper cone type speakers, PN 1663-001.

DCARTS-056-4 10/31/91 **All PALs (Programmable Array Logic Chips) shipping in current products have a part number change to reflect a new raw PAL that is now being used.**

Old and new PALs are pin-for-pin compatible. (See Tech Memo for details.)

DCARTS-058-3
10/31/91

Announces the release of 008/108 software.

The new software supports the AM-4 acquisition module. The 008 and 108 software versions are identical with the exception being the size of the EPROM that is used. (See Tech Memo for EPROM part numbers.)

DCARTS-059A-3
12/15/91

Inability to transmit from a MAC PC electrocardiograph to the MUSE Network Series system via local line.

Modify MUSE Network Series systems that support local line acquisition.

Symbols

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