CRAY Y-MP Power Distribution And Refrigeration Maintenance Manual

CMMXXXXXXX
5/88

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REVISION	DESCRIPTION
May, 1988	Original Printing

PREFACE

This publication describes the operation and maintenance of the power distribution and refrigeration systems for the CRAY Y-MP computer system manufactured by Cray Research, Inc. (CRI).

AUDIENCE

This manual is written to assist field engineers (FEs) and assumes a familiarity with digital computers.

ORGANIZATION

This manual is organized as follows:

SECTION 1 - OVERVIEW OF POWER DISTRIBUTION AND REFRIGERATION provides introductory material to power distribution and refrigeration in the CRAY Y-MP computer system, including block diagrams.

SECTION 2 - CONTROL SYSTEM describes theory of operation, console operation, monitoring operation, and a description of how the control system powers up and powers down the mainframe and auxiliary equipment in the event of system faults.

SECTION 3 - POWER DISTRIBUTION describes the Motor Generator Set (MGS), power supplies, and busing in the mainframe.

SECTION 4 - COOLING describes the Heat Exchange Unit (HEU), and the mainframe Refrigeration Condensing Unit (RCU-1) and auxiliary RCU (RCU-2).

SECTION 5 - MAINTENANCE AND TROUBLESHOOTING describes maintenance and troubleshooting information for the control system, , RCUs, MGS, HEU, and power supplies.

WARNINGS, CAUTIONS, NOTES

WARNING

The CRAY Y-MP computer system operates in accordance with the FCC's Part 15 Subpart J Rules under exemption Rule 15.801 (c) (3) adopted August 5, 1986.

RELATED PUBLICATIONS

Refer to the following CRI publications for related information on CRAY Y-MP computer system power disribution and refrigeration:

- *Instruction Manual for Cray Research, Inc., Motor Generator Sets, 150 KW, 167 KVA, 60 to 400 Hertz.* This manual, provided by KATO Engineering, contains drawings and wiring diagrams, and describes MGS controls and other parts.

- HR-4001 *CRAY Y-MP Functional Description.* This manual describes the CRAY Y-MP system components and support equipment, hardware architecture of the mainframe, and CPU instructions

- CRI Engineering Specification 02254500. *RCU-1 Condensing Unit Installation Specification.* This specification describes the checkout procedure for a replacement compressor for the RCU-1.

- CRI Engineering Specification 02253700. *RCU-2 Condensing Unit Installation Specification.* This manual describes the checkout procedure for a replacement compressor for the RCU-2.

- HR-4000 *CRAY Y-MP/8 Site Planning Reference Manual.* This manual provides site planning information for the CRAY Y-MP mainframe, the I/O Subsystem (IOS), the Solid-state Storage Device (SSD), and the IOS and SSD Power Distribution Units (PDUs).

- HR-0082 *Cray Support Equipment Site Planning Reference Manual.* This manual provides site planning information for RCUs and MGS's.

- HR-0306 *Safe Use and Handling of Fluorinert.* This manual contains warnings and cautions regarding the use of Fluorinert.

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FIGURES

FIGURES (continued)

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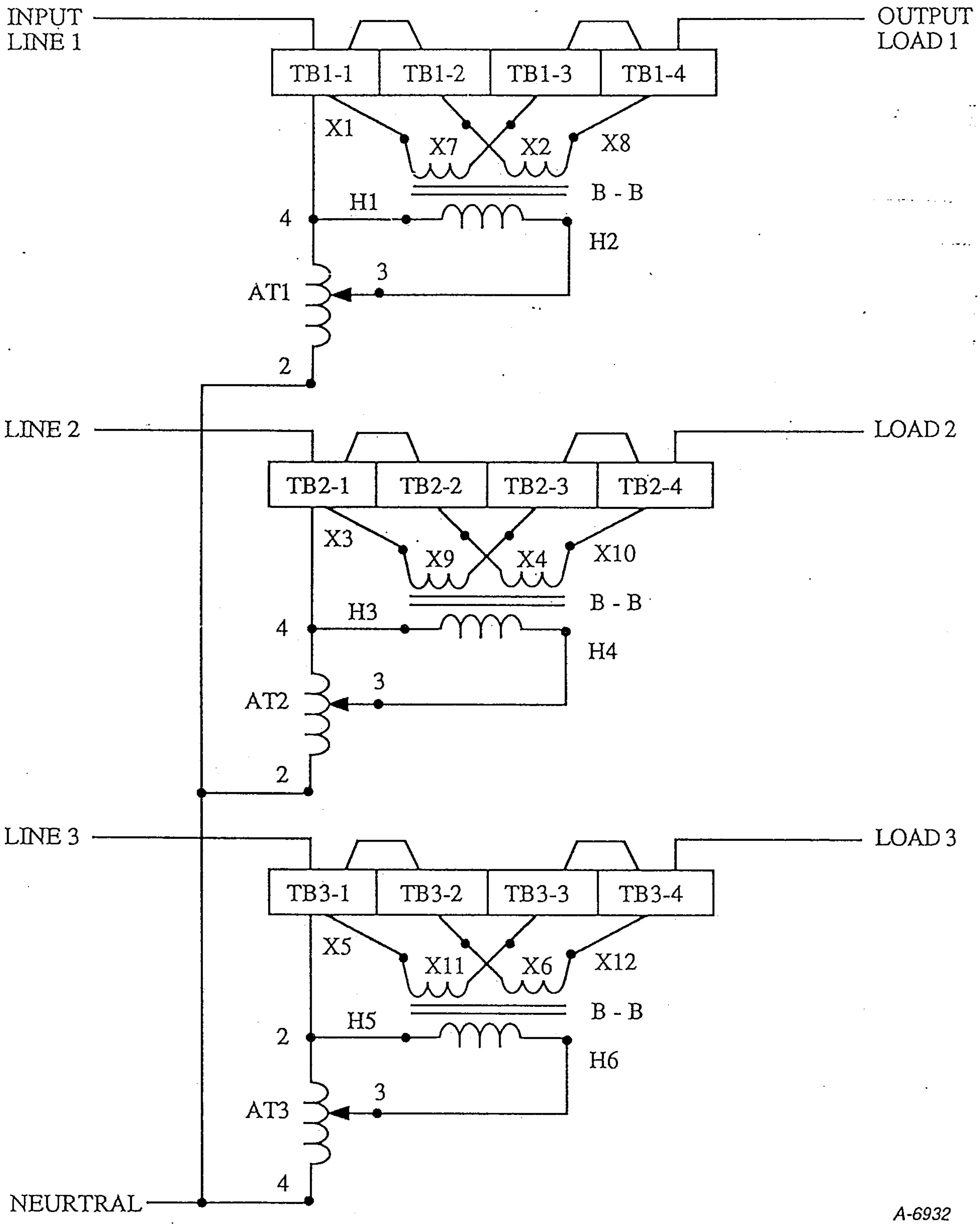

INPUT
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OUTPUT
LOAD 1
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TB1-2
TB1-3
TB1-4
X1
X7
X2
X8
B - B
H1
4
H2
3
AT1
2
LINE 2
LOAD 2
TB2-1
TB2-2
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TB2-4
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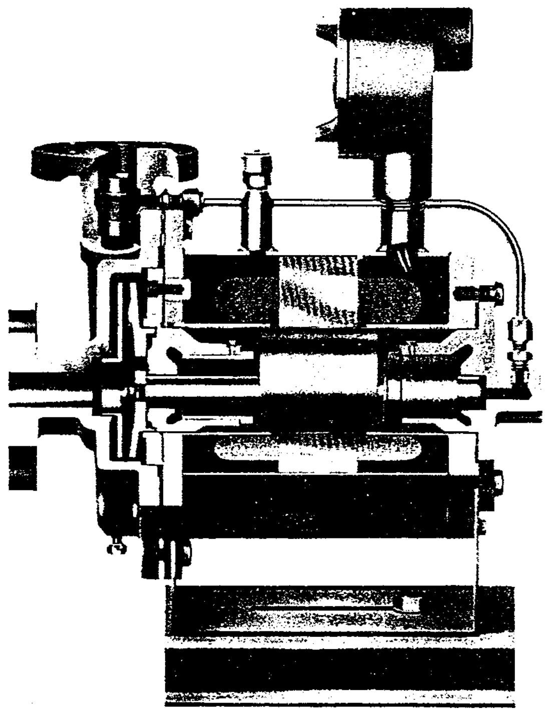
INSTRUCTION MANUAL

FOR
INSTALLATION
OPERATION
MAINTENANCE

CRANE CHEMPUMP

SEAL-LESS LEAKPROOF CANNED MOTOR PUMPS



SERIES G

CRANE

VALVES • PUMPS • FITTINGS • WATER TREATMENT • PLUMBING
Chempump Division • Warrington, Penna. • (215) 343-6000

SERIES G CHEMPUMP

INSTRUCTION MANUAL

Installation, Operation, and Maintenance Instructions for Single-Stage Models:

GA	GVE
GB	GVH(S)
GC	GG
GD	GVM
GVD	GVBS
GE	

and Two-Stage Models:

GLD
GFD
GHD

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INSTRUCTION MANUAL
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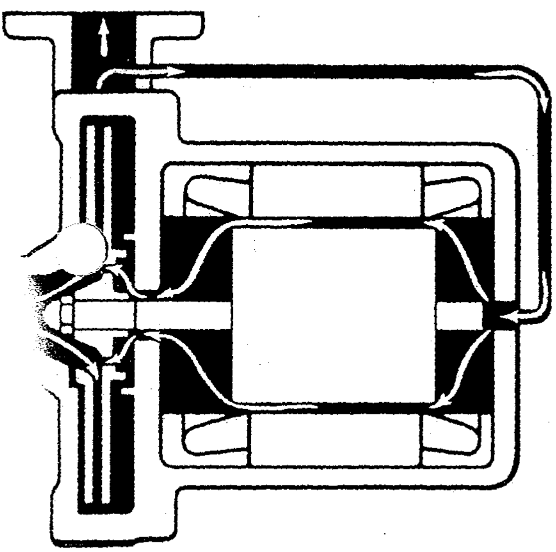
SERIES G CHEMPUMP INSTRUCTION MANUAL

.ION 1. General Information

General Design and Operation

npump has only one moving part, a combined -impeller assembly which is driven by the magnetic of an induction motor. A small portion of the ed fluid is allowed to recirculate through the rotor to cool the motor and lubricate the bearings. The windings are protected from contact with the ulating fluid by a corrosion-resistant non-magnetic liner which completely seals or "cans" the stator ngs. The recirculating fluid passes through a self ing cylindrical filter (fitted in the discharge neck e pump casing), through the circulation tube, to ear of the pump. It then moves across the rear ng, across the rotor, across the front bearing and into the low pressure side of the main discharge (see Figure 1-1, Page 1.)



l Series G Chempump Schematic Diagram Single Stage

rge filter (see Figure 1-2, Page 1), located harge neck of the pump casing, helps to ex- and bearing life by keeping the circulating f damaging particles. Although this filter is d bottom, and is constantly washed by the ow, it should receive periodic inspection for d particle build-up in the counter bore be- een. Also, certain types of solids are gummy here to the fine wire mesh, thus restricting earings.

mp seal-less pump is a precision-built unit oper care, will give years of trouble-free, vice. This manual, containing basic in- in ation, operation and maintenance s, designed to assist you in obtaining

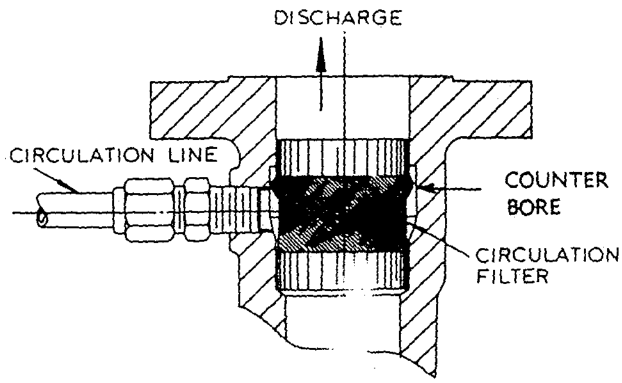


Figure 1-2 Discharge Filter Arrangement

It is important that the persons responsible for the installation, operation, and maintenance of the pump, read and understand the manual thoroughly.

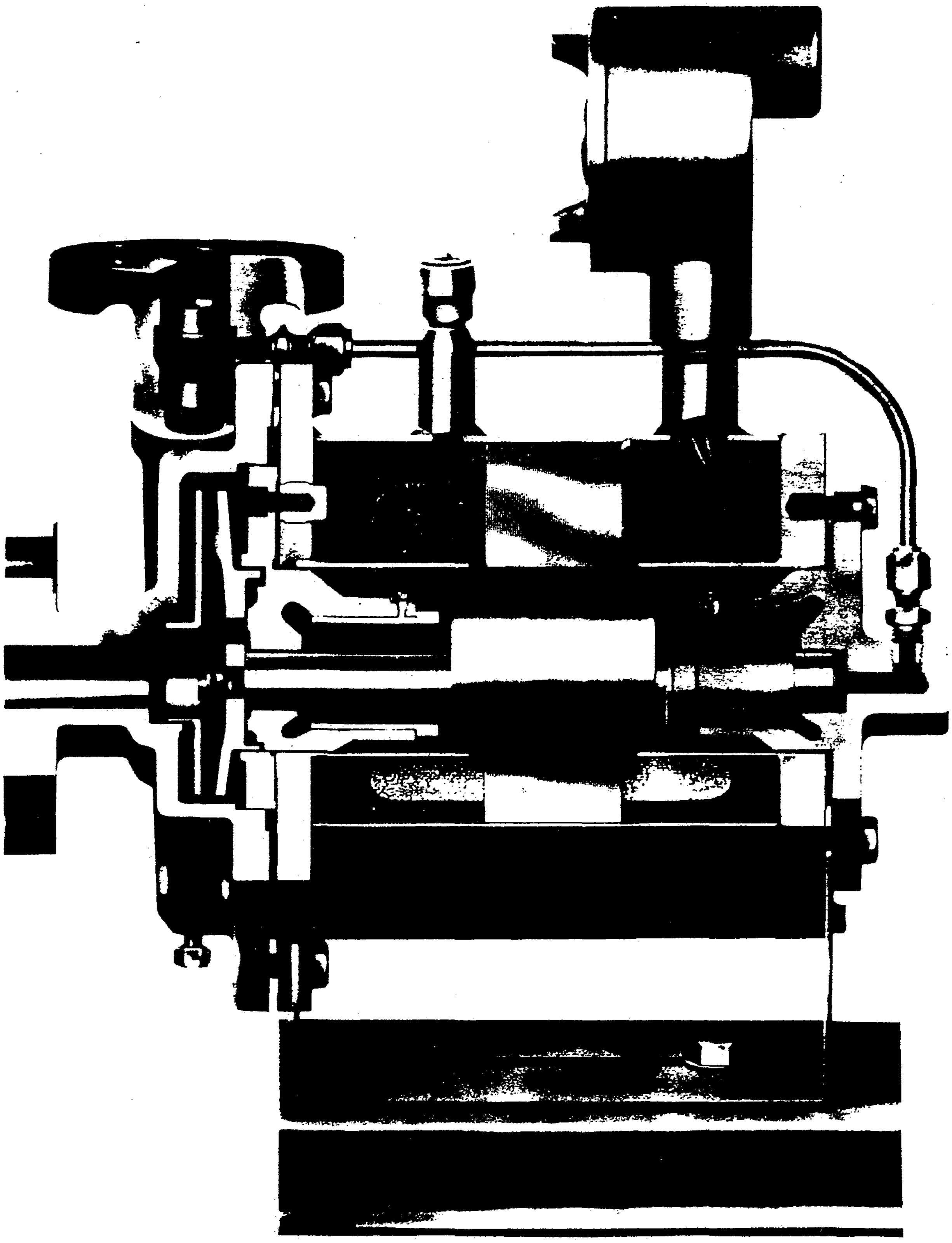
Trouble-free Chempump performance begins with proper pump selection and application. If the selected pump does not have the required performance characteristics, or if the materials of construction are not properly specified for the fluid being handled, unsatisfactory operation may result. No amount of maintenance can compensate for this.

If you are in doubt on Chempump selection or application, write or call your Chempump engineering representative or the factory for assistance and advice.

Additional copies of this manual are available from the Chempump field representative or from the factory.

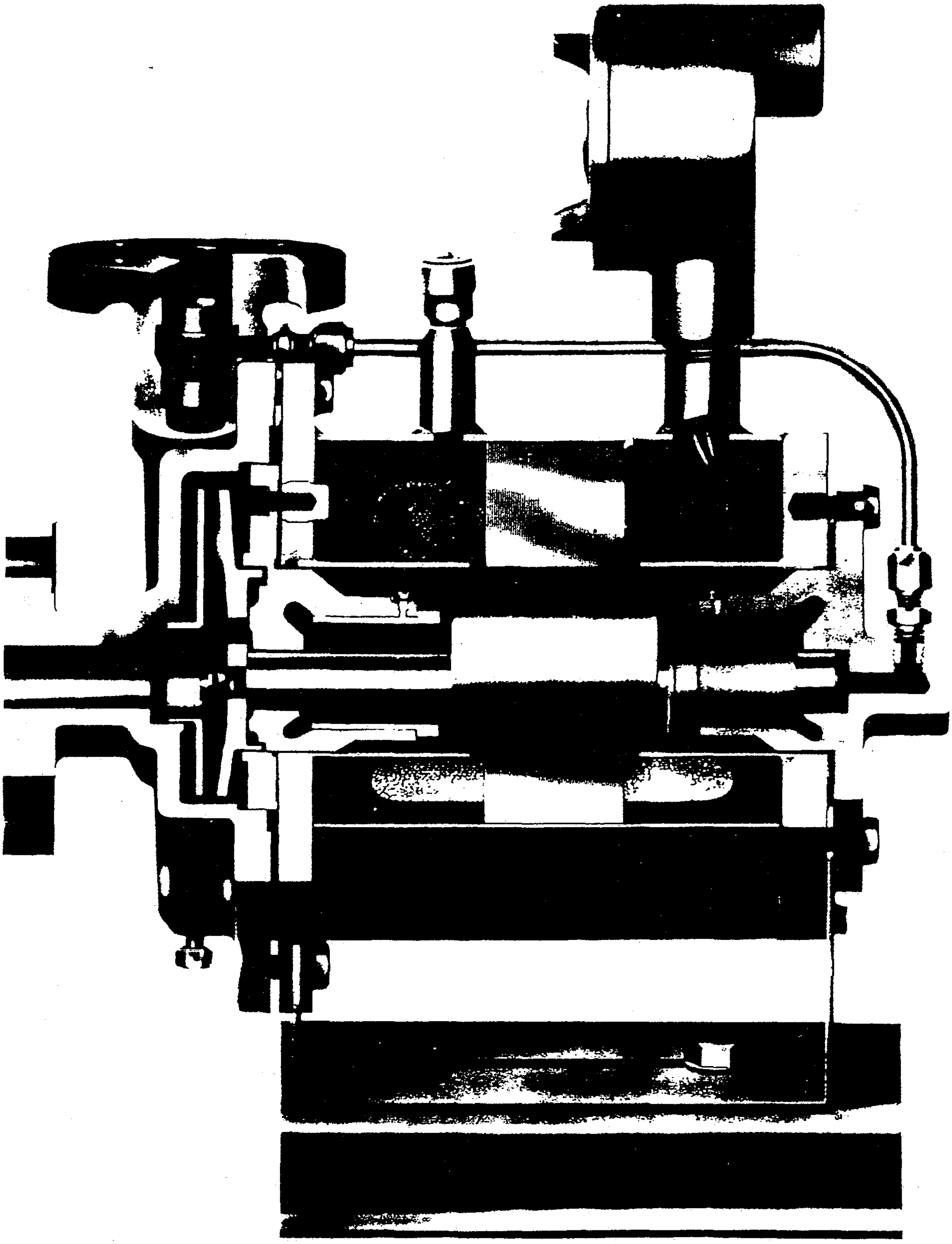
The unit is essentially a centrifugal pump and a squirrel cage induction electric motor, built together into a single hermetically sealed unit. The pump impeller is of the closed type, and is mounted on one end of the rotor shaft which extends from the motor section into the pump casing. The rotor is submerged in the fluid being pumped and is therefore "canned" to isolate the motor parts from contact with the fluid. The stator winding is also "canned" to isolate it from the fluid being pumped. Bearings are submerged in system fluid and are therefore automatically lubricated.

The entire unit is mounted on a fabricated steel base plate. Operation is unaffected by the mounting or operating position. (See Figure 1-3, Page 2. See Figure 1-4, Page 3).



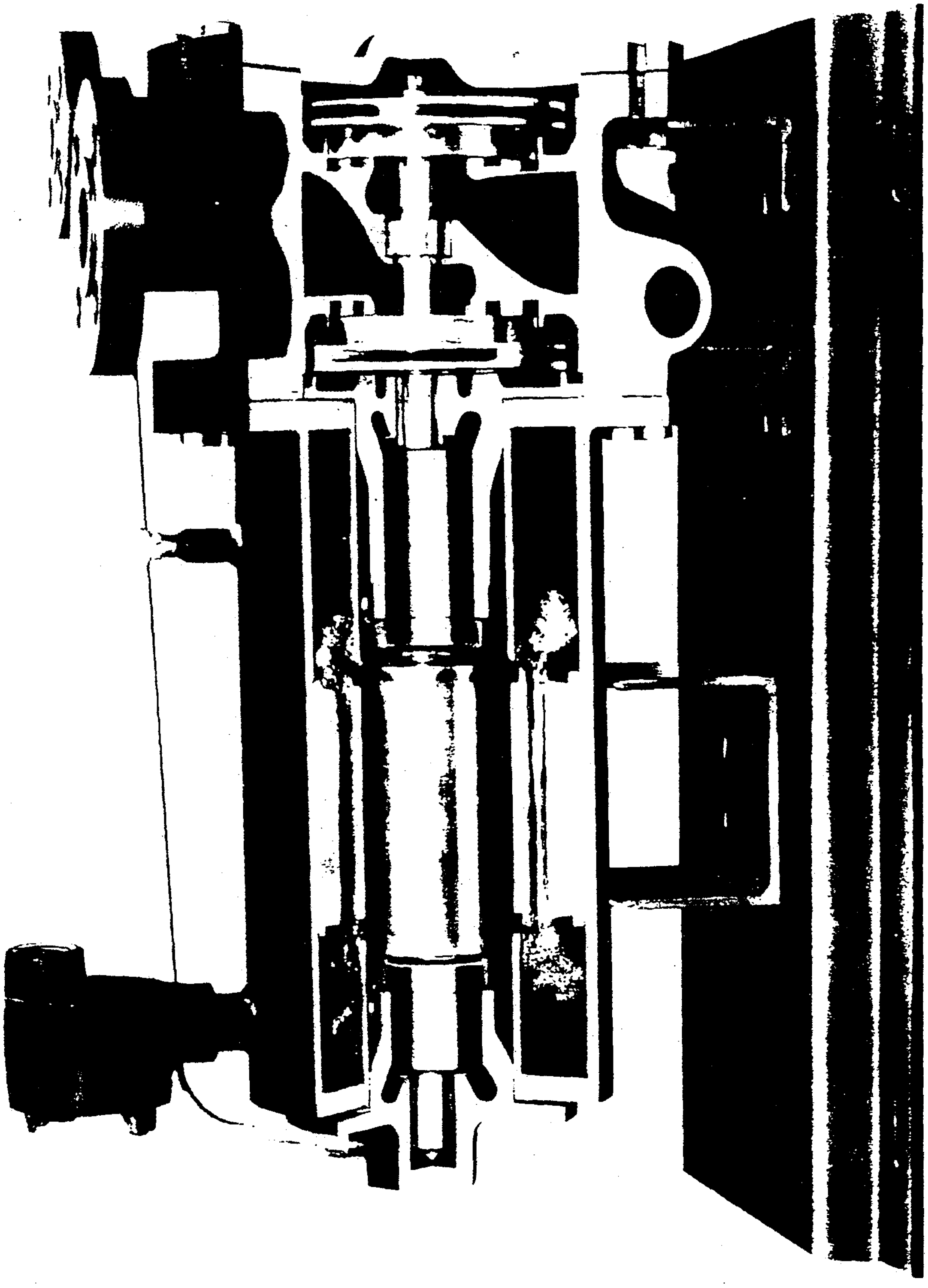
MODELS GA, GB, GC, GD, GE, GG, GVM, GVD, GVE, GVH(S), GVBS CHEMPUMPS

Figure 1-3



MODELS GA, GB, GC, GD, GE, GG, GVM, GVD, GVE, GVH(S), GVBS CHEMPUMPS

Figure 1-3



MODELS GFD, GHD, GLD CHEMPUMP

Figure 1-4

1-2. Stator Assembly

The stator assembly consists of a set of three-phase windings connected in a one circuit wye arrangement. Stator laminations are of low-silicon grade carbon steel. Laminations and windings are mounted inside the cylindrical stator band. End bells, welded to the stator band, close off the ends of the stator assembly. Back up sleeves are provided to strengthen those areas of the stator liner not supported by the stator laminations. The stator liner is, in effect, a cylindrical "can", placed under the stator bore and welded to the end bell shrouds to hermetically seal off the windings from contact with the liquid being pumped. Terminal leads from the windings are brought out through a pressure tight lead connector, mounted on the stator band, to a standard connection box.

1-3. Rotor Assembly

The rotor assembly is a squirrel cage induction rotor constructed and machined for use in the Series G Chempump. It consists of a machined stainless steel shaft, laminated core with aluminum bars and end rings, two stainless steel end covers, and a stainless steel can. The shaft is provided with flats or with an impeller key arrangement at one end to receive the impeller and is threaded at the same end to receive the impeller nut which retains the impeller, or impellers in the case of two-stage models.

The two rotor end covers are welded to the shaft and also to the rotor can which surrounds the outside of the rotor, thus hermetically sealing off the rotor core from contact with the liquid being pumped.

1-4. Bearings

The bearings for the unit are metal sleeved, have a molded carbon/graphite insert as standard (other materials are furnished depending on the application), and are machined with a special helix groove through the bore to assure adequate fluid circulation at the journal area. Each bearing is manufactured to close tolerances for a high degree of concentricity, and is held in a bearing housing by a retaining screw and lock washer. Bearings are easily replaced by removing the retaining screw and sliding the bearing from its housing. (See Figure 1-5, Page 4.)

Single-stage models are provided with two bearings in the motor end, while two-stage models are provided with two bearings in the motor end plus another bearing (idler bearing) in the pump casing for additional shaft support.

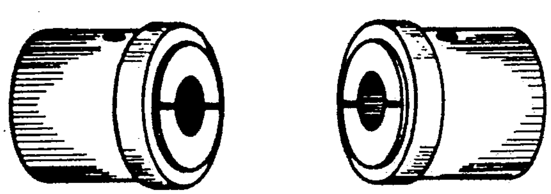


Figure 1-5—Bearings Series G Chempump
Sleeved Type—Standard in all Models

1-5. Cooling Flow

Cooling for stator, rotor, and bearings, as well as bearing lubrication, is provided by circulation of the pumped fluid. A small flow circulates through the circulation tube, through the rear bearing housing, across the rear journal, over and around the rotor, across the front journal and front bearing housing, through the eye of the impeller, and returns to the main stream flow. (See Figure 1-1, Page 1.)

1-6. Automatic Thrust Balance

A) Single Stage Models GA, GB, GC, GVBS

Based on hydraulic principles, Chempump's automatic thrust balance is accomplished by the pressure of the pumped fluid itself, operating in a balance chamber just to the rear of the impeller.

When a change in load tends to change the position of the impeller away from the balanced condition, there is an equalizing change of hydraulic pressure in the balance chamber which immediately returns the impeller-rotor assembly to the balanced position. (See Figure 1-6, Page 4.)

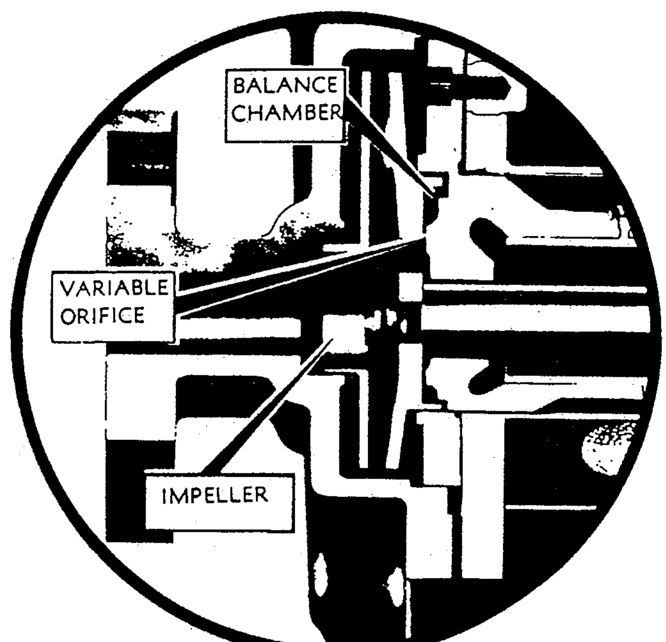


Figure 1-6 Automatic Thrust Balance, Single Ring

B) Single Stage Models GD, GE, GVD, GVE, GVH(S), GG, GVM

Automatic thrust balance on these models operates on the same principle as noted above except that balance chambers are provided on the front as well as the rear of the impeller to absorb the additional axial thrust loading of these larger models. (See Figure 1-7, Page 5.)

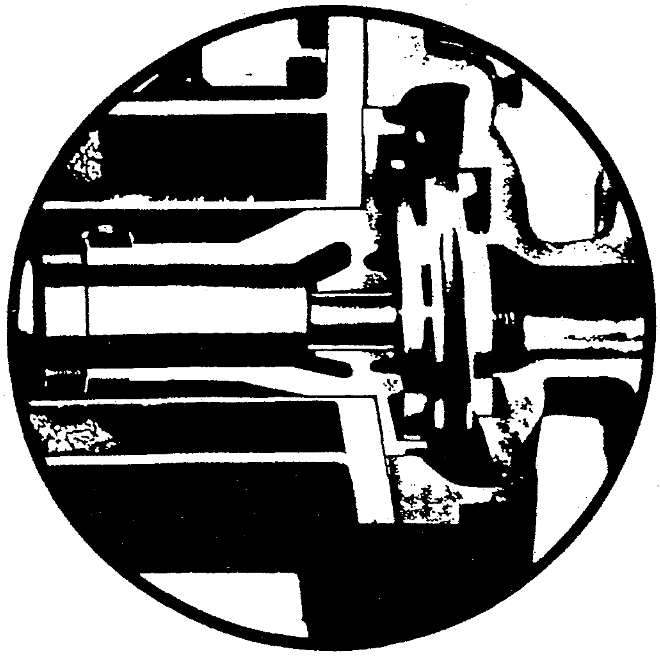


Figure 1-7 Automatic Thrust Balance, Double Ring

C) Two-Stage Models GLD, GFD, GHD

Axial hydraulic thrust, on these models, is balanced by identical opposing impellers, each equipped with equalizing wearing rings designed to automatically regulate the amount of fluid recirculating around the impellers.

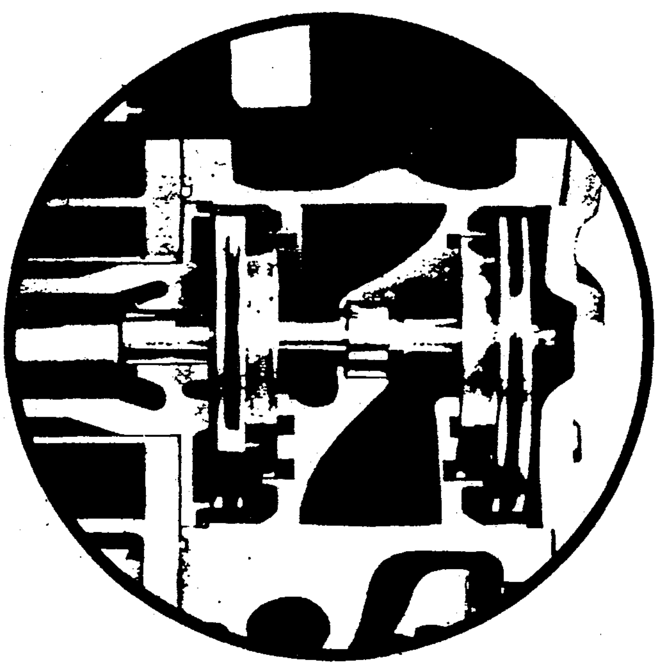


Figure 1-8 Automatic Thrust Balance, 2-Stage

SECTION 2. Installation

2-1. Receipt Inspection

1. Visually inspect the shipping container for evidence of damage during shipment.
2. Check unit to see that suction and discharge connections are sealed.
3. Inspect the suction and discharge gasket seating surface to be certain that they are clean of foreign matter and free from nicks, gouges and scratches.
4. Visually inspect the unit for evidence of shipping damage.
   a. Circulation line not bent or compressed
   b. Flange faces
   c. Junction box and nipple in stator assembly not bent or compressed
   d. Vent and drain plugs are properly installed
5. Megger resistance to ground of the motor windings. (See Table 4-4, Page 25.)
6. Check all nameplate data against shipping papers.
7. Caution should be observed during handling so as not to bend the circulation line.

2-1,1. Storage Note

In situations where a Chempump is to be stored for a period of time prior to installation, and where the climate experiences wide temperature changes and high humidity, the terminal box must be sealed to prevent moisture from entering the motor winding area.

2-2. Structural

The pump design and construction eliminates the necessity of aligning the pump and motor. The pump should be supported from the mountings provided. It should be mounted in such a way as to have its weight properly supported. Suction and discharge piping must be properly supported and aligned so that no strain is placed on the pump casing.

General

1. Remove burrs and sharp edges from flanges when making up joints.
2. When connecting flanged joints, be sure inside diameters match within 1/16" diametrically so as not to impose a strain on the pump casing.
3. Use pipe hangers or supports at intervals as necessary.

2-2,1. Pump Location

Locate the pump as close as possible to the fluid supply with a positive suction head. Installations with suction lift are possible but not recommended.

Since standard pumps are not self-priming, provide for initial priming and for maintaining a primed condition. Location of the pump and arrangement of the system should be such that sufficient NPSH (Net Positive Suction Head) is provided over vapor pressure of the fluid at the pump inlet. NPSH requirements at the design point are stated on the pump order copy. For additional design points, refer to the corresponding performance curves placed in the back of this manual.

NOTE

> Experience has proved that more pump troubles result from insufficient NPSH than from any other single source. Available NPSH *MUST* be greater than required NPSH.

Depending on job conditions, available NPSH can sometimes be increased to suit that required by the pump for satisfactory operation. NPSH can be 'tailored' by changes in the piping, in liquid supply level, by pressurizing the suction vessel and by several other methods. See Maintenance Trouble Shooting, Table 4-3, Pages 20 and 21.

2-2,2. Mounting and Alignment

The Chempump combines a pump and motor in a single hermetically sealed unit. No tedious coupling alignment is required because the pump has no external coupling between pump and motor. All models can be mounted in any position except two-stage Models GFD, GHD and GLD, which must be mounted with suction and discharge "up" unless otherwise allowed. For mounting with suction and discharge on the side or in any other position, modifications must be made to the standard internal venting arrangement.

Standard Models GA, GB and GC Chempumps can be pipeline mounted. However, bases are offered on all models. Merely set the pumps on a foundation strong enough to support their weight. There is no need to bolt down or grout in a Chempump. All Series G models are provided with a specially made base, designed to facilitate inspection and repair. See Figure 2-1, Page 7.

Be sure that suction and discharge piping is properly aligned so that no strain is placed on the pump casing by out-of-line piping.

2-2,3. Piping Data

Observe the standards of the Hydraulic Institute when sizing and making up suction and discharge piping. Follow these procedures:

1. Remove burrs and sharp edges when making up joints.
2. When using flanged joints, be sure inside diameters match properly. When gasketing flanged joints, DO NOT cut flow hole smaller than flange opening.
3. Use pipe hangers or supports at necessary intervals.
4. Provide for pipe expansion when required by fluid temperature.

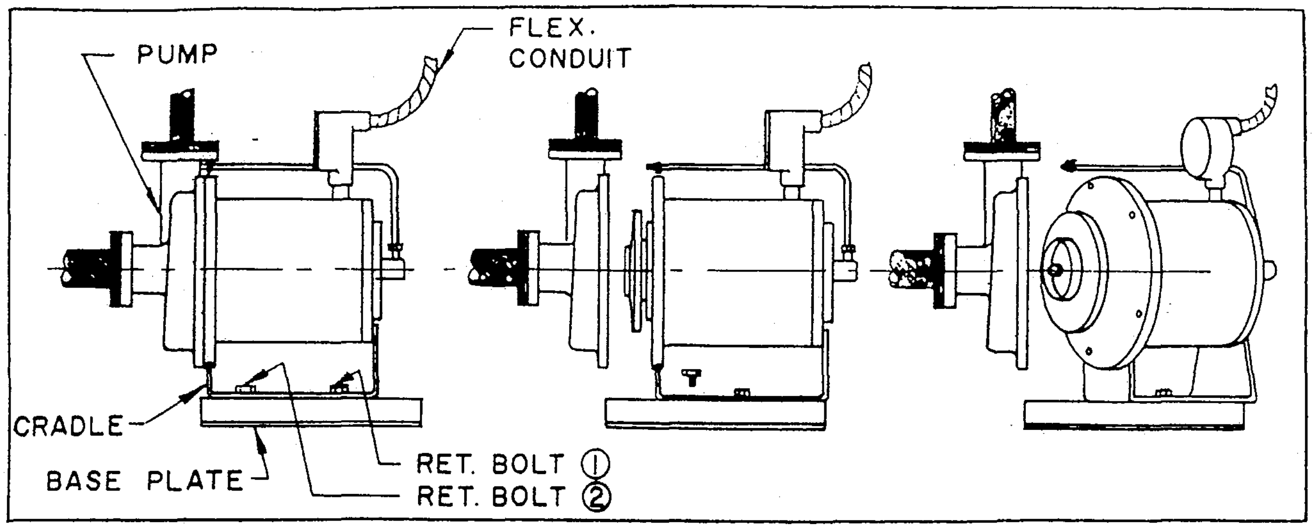


Figure 2-1 Easy Maintenance Base

5. When welding joints, avoid possibility of welding shot entering line, and thereby entering pump. Do not weld pipe while connected to pump.
6. When starting up a new system, place a temporary 3/16" mesh screen at or near suction port of pump to catch welding shot, scale or other foreign matter. **Screen should not remain in line longer than 24 hours after start-up.** Avoid the possibility of a clogged screen starving the pump. The screen should have a net area of at least three times the area of the suction pipe.
7. Do not spring piping when making up any connections.
8. Make suction piping as straight as possible, avoiding unnecessary elbows. Where necessary, use 45° or long-sweep 90° fittings.
9. Make suction piping short, direct, and never smaller in diameter than suction opening of pump. Suction piping should be one or two sizes larger than pump suction port, depending on pipe length.
10. Insure that all joints in suction piping are airtight.
11. Install valves and other fittings in positions to avoid formation of air pockets.
12. Permanently mounted suction filters are not recommended.

It is extremely important to size and layout the suction system to minimize pressure losses and to be sure that the pump will not be 'starved" for fluid during operation. NPSH problems are a result of improper suction systems.

If suction pipe length is short, pipe diameter can be the same size as the pump suction port diameter. If suction piping is long, the size should be one or two sizes larger than pump suction port, depending on piping length. Use the largest pipe size practical on suction piping and keep piping short and free from elbows, tees or other obstacles. If elbows or tees must be used, locate them from 10 to 15 pipe diameters upstream from suction. When reducing to pump suction port diameter, use eccentric reducers with eccentric side down to avoid air pockets.

When operating under conditions where pump prime can be lost during off cycles, a foot valve should be provided in the suction line to avoid the necessity of priming each time the pump is started. This valve should be of the flapper type rather than the multiple spring type and of ample size to avoid undue friction in the suction line.

When foot valves are used, or when there are other possibilities of fluid hammer, it is important to close the discharge valve before shutting down the pump.

When necessary to connect two or more pumps to the same suction line, provide gate valves so that any pump can be isolated from the line. Install gate valves with stems horizontal to avoid air pockets. Globe valves should be avoided, particularly where NPSH is critical.

If discharge pipe length is normal, pipe diameter can be the same size as the pump discharge port diameter. If discharge piping is of considerable length, use larger diameter pipe (one or two sizes larger).

If the pump is to discharge into a closed system or an elevated tank, place a gate valve or check valve in the discharge line close to the pump. The pump can then be opened for inspection without fluid loss or damage to the immediate area.

RECOMMENDED: Install properly sized pressure gauges in suction and discharge lines near the pump ports so that operation of the pump and system can be easily observed. Should cavitation, vapor binding, or unstable operation occur, widely fluctuating discharge pressures will be observed.

Such gauges provide a positive means of determining actual system conditions and can be used to great advantage in evaluating system problems.

2-3. Electrical

2-3,1. General

Except where indicated, all Chempumps are started with full line voltage. Connections for high and low voltage are shown on the voltage connection portion of the nameplate; phase sequence also is shown. (See Paragraph 3-3, Page 16 for checking direction of rotation) Also see Figures 2-2, 2-3, or 2-4 depending on electrical source characteristics, Page 9.

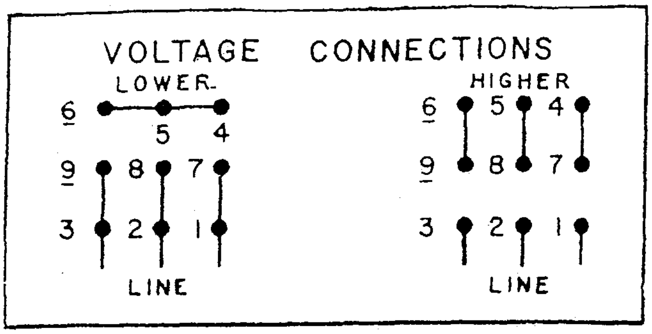


Figure 2-1A 3-Phase, Dual-Voltage Connections

2-3,2. Thermal Cut-Out

Unless otherwise specified, all Chempumps are fitted with thermal cut-outs. The cut-out is a heat-sensitive bimetallic switch, mounted in intimate contact with the stator windings. It is to be wired in series with the holding coil in the starter box by removing a jumper as shown in Figures 2-2, 2-3 or 2-4, Page 9. See Table 21 for TCO maximum holding coil currents, Page 8.

Table 2-1

TCO Maximum Holding Coil Currents

115 Volt	**3.1 Amps**
230 Volt	**1.6 Amps**
460 Volt	**0.8 Amps**

IMPORTANT: For maximum TCO contact life, it is recommended the 115 volt holding coil circuit be used where possible and that the holding coil current be kept to a minimum. Maximum holding coil currents are as above.

WARNING

Do not connect TCO in series with main power lead. Excessive heat building in the winding area opens the normally closed thermal switch, which in turn opens the holding coil circuit, shutting off power to the pump. Be sure to connect the thermal cut-out as required.

Thermal cut-outs in Class A insulated motors are set to open at 240°F; and Class H insulated motors at 425°F. Depending on the application, specially set TCO's are sometimes provided. The pump order copy indicates the TCO setting. If the motor cuts out because of TCO action, there will be a time delay before the motor can be restarted. The motor must be restarted manually. DO NOT RESTART UNTIL YOU DETERMINE THE SOURCE OF THE OVERHEATING.

WARNING

The thermal cut-out switch does not provide protection against fast heat build-up resulting from locked rotor conditions, single phasing or heavy overloads. This protection must be provided for by the current overload relay heaters in the magnetic starter. The rating of the heaters should be high enough to avoid nuisance cut outs under running loads, but must not be oversized. Refer to Table 2-2, Page 10 for starting and running electrical characteristics. It is recommended that "quick trip" type heaters be used.

2-3,3. Starting Equipment

Motor starters (normally not supplied with Chempump) should be sized to handle the load required. Start KVA, Full Load KW, Full Load Amps and Full Load KVA data are given in Table 2-2, Page 10.

Heaters in the starters should be sized for the amperage shown on the Chempump nameplate. DO NOT size heaters in excess of 10% of full load amp rating. In order to provide complete protection for Chempump motors under all conditions, it is recommended that "quick trip" type heaters be used in the starters where available. Standard type heaters can be used if these "quick trip" type heaters are not available. Standard heaters provide adequate protection for Chempump motors under starting or normal running conditions, but require a greater length of time than "quick trip" type heaters to cut out, when and if the motor is subject to locked rotor or overload conditions. Also see Tables 2-3, 2-4, or 2-5, Pages 10 and 11 for additional electrical wiring data for the most common Chempump motor sizes to assist in the electrical installation of the unit.

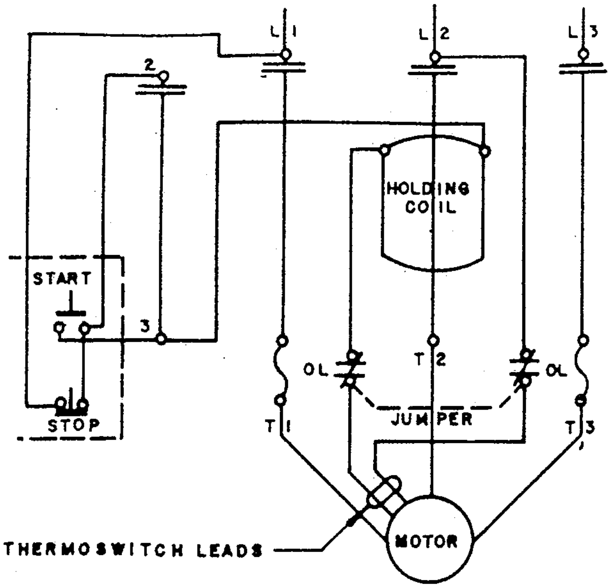


Figure 2-2 Wiring Diagram—230/460 Volt, 3 Phase

CASE II — 575 VOLT, 3-PHASE CHEMPUMP
(See Figure 2-3)

Use transformer with 575-volt primary and 115- or 230-volt secondary. Use properly rated holding coil (115 or 230 volt).

Wire Thermoswitch as for 230 or 460 volt systems described in Case I above.

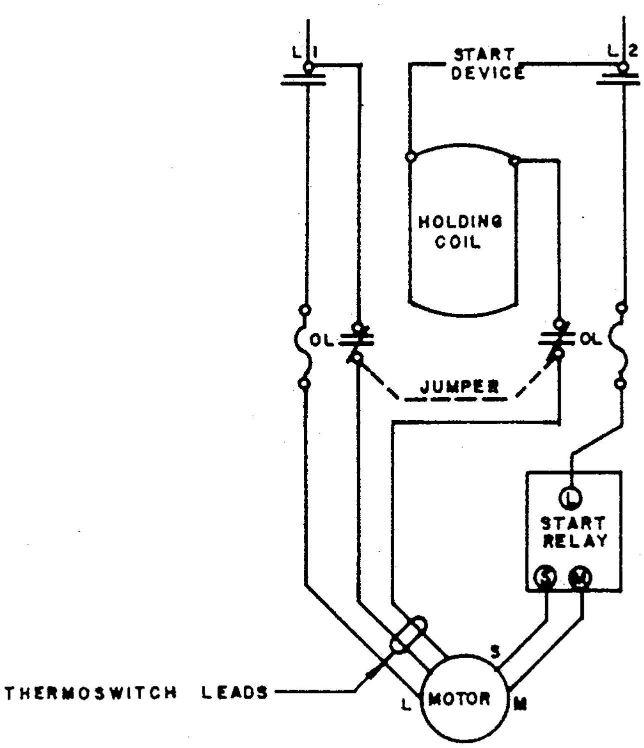


Figure 2-4 Wiring Diagram 115/230 Volt, 1 Phase

CASE I — 230/460 VOLT, 3-PHASE CHEMPUMP
(See Figures 2-1A and 2-2)

Typical 3-phase across-the-line magnetic starter with start-stop push button station shown.

Thermoswitch (thermal cut-out inside Chempump motor) is wired in series with holding coil circuit by removing jumper between overload cutouts, as shown.

Be sure to size heaters properly. Rating should be as close as possible to current draw noted on pump nameplate.

Refer to Figure 2-1A for voltage connections.

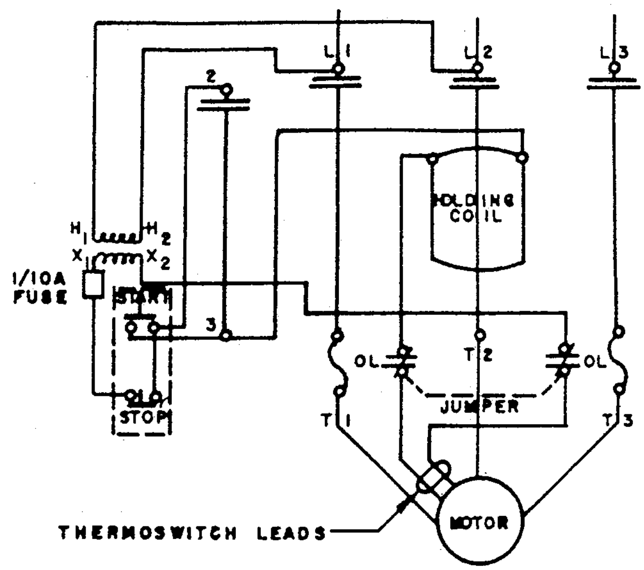


Figure 2-3 Wiring Diagram—575 Volt, 3 Phase

CASE III — SINGLE PHASE, 115-or-230 VOLT SPECIAL CHEMPUMPS
(See Figure 2-4)

Typical single phase across-the-line magnetic starter with start device not shown.

Thermoswitch is wired in series with holding coil circuit after removing jumper as in Case I above.

Start relay is supplied by Chempump.

NOTE: MOTOR LEAD "L" MAY BE SINGLE WIRE OR TWO WIRES TIED TOGETHER AT FACTORY.

Table 2-2
Series G Electrical Data

Model	Motor Size	Start KVA	FULL LOAD RATINGS KVA	KW	Amperes 230V	460V	575V
GA	1K	5.06	1.9	1.5	4.6	2.3	1.84
GA, GB, GC	1-1/2K	10.39	3.05	2.5	7.7	3.83	3.06
GB, GC, GVBS, GLD	3K	20.77	5.3	4.4	13.4	6.70	5.36
GB, GC, GVBS, GLD	5K	28.4	7.02	5.9	17.6	8.8	7.04
GD, GE, GFD, GVD, GVE	5K	34.6	9.9	8.5	24.8	12.4	9.9
GD, GE, GFD, GVD, GVE, GVH(S)	7-1/2K	52.04	12.5	11.0	31.6	15.8	12.6
GD, GE, GG, GFD, GHD, GVD, GVE, GVH(S)	10K	69.2	17.5	15.5	44.0	22.0	17.6
GD, GE, GG, GFD, GHD, GVD, GVE, GVH(S)	15K	104.25	22.2	20.0	55.6	27.8	22.2
GD, GE, GG, GFD, GHD, GVD, GVE, GVH(S)	20K	138.8	30.8	27.0	77.6	38.8	30.9
GVM (1150 rpm)*	5P	25.0	7.15	5.0	17.66	8.83	7.05
GVM (1750 rpm)*	7-1/2L	38.5	10.7	7.5	27.0	13.5	10.8
	10L	48.5	13.1	10.0	33.4	16.7	13.4
	15L	62.7	16.5	13.5	41.2	20.6	16.5

Table 2-3
Electrical Wiring Data for 230-Volt, 3-phase, 60 Hertz Chempumps

Chempump Model	Motor Size	Full Load Speed (rpm)	Switch Size Amps	Breaker Size Amps	Starter NEMA Size	Conductor Size for Motor Leads	Conduit Size for Motor Leads Only	Conduit Size for Motor, PB & TCO Leads	Fuse Size Code and Current Limiting Amps	Fuse Size Dual Element Amps	Max. Setting of Time Limit Overload Protection Amps
GA, GB, GC, GVBS, GLD	1K	3450	30	15	0	14	1/2	3/4	15	7	5.3
	1-1/2K	3450	30	20	0	14	1/2	3/4	25	12	9.5
	3K	3450	60(30)	40	1	12	1/2	3/4	45	20	17.2
GB, GC, GVBS, GLD	5K	3450	60(30)	50	1	10	3/4	1	50	25	21.8
GD, GE, GG, GFD, GVD, GVE	5K	3450	100(60)	70	2	10	3/4	1	80	40	31.8
GD, GE, GG, GFD, GHD, GVD, GVE GVH(S)	7-1/2K	3450	100(60)	100	2	6	1	1-1/4	90	45	38.5
	10K	3450	200(100)	125	3	6	1	1-1/4	125	70	55.0
	15K	3450	200(100)	150	3	4	1-1/2	1-1/4	175	80	70.0
	20K	3450	200(150)	200	3	2	1-1/2	1-1/2	200	100	97.0
GVM (1150 rpm)*	5P	1150	60(30)	40	1	12	1/2	3/4	50	25	20.5
GVM (1750 rpm)*	7-1/2L	1750	100(60)	70	1	8	3/4	1	90	45	34.4
	10L	1750	100(60)	100	1	8	3/4	1	100	50	41.5
	15L	1750	200(60)	125	2	6	1	1-1/4	125	60	52.1

*( ) Brackets indicate reduction in switch size when dual-element fuses are used for motor branch circuits. (Except where noted, the switch sizes are the same for all types of fuses.)
Select "quick trip" heaters on the basis of start KVA with a 12 second maximum time.

Table 2-4

Electrical Wiring Data for 460-Volt, 3-Phase, 60 Hertz Chempumps

Chempump Model	Motor Size	Full Load Speed (rpm)	Switch Size Amps	Breaker Size Amps	Starter NEMA Size	Conductor Size for Motor Leads	Conduit Size for Motor Leads Only	Conduit Size for Motor, PB & TCO Leads	Fuse Size Code and Current Limiting Amps	Fuse Size Dual Element Amps	Max. Setting of Time Limit Overload Protection Amps
GA, GB, GC, GVBS, GLD	1K	3450	30	15	0	14	1/2	3/4	15	3-1/2	2.7
	1-1/2K	3450	30	15	0	14	1/2	3/4	15	7	4.8
	3K	3450	30	15	1	14	1/2	3/4	20	10	8.2
GB, GC, GVBS, GLD	5K	3450	30(15)	20	1	14	1/2	3/4	30	15	20.0
GD, GE, GG, GFD, GVD, GVE	5K	3450	60(30)	40	1	12	1/2	3/4	40	20	16.1
GD, GE, GG, GFD, GHD, GVD, GVE, GVH(S)	7-1/2K	3450	60(30)	40	2	10	3/4	1	50	25	18.0
	10K	3450	100(60)	60	2	10	3/4	1	70	35	27.5
	15K	3450	100(60)	70	3	6	1	1-1/4	80	40	34.6
	20K	3450	200(100)	100	3	6	1	1-1/4	125	60	47.8
GVM (1150 rpm)	5P	1150	30	30	1	12	1/2	3/4	30	15	11.2
GVM (1750 rpm)	7-1/2L	1750	60(30)	40	1	12	3/4	1	45	25	17.2
	10L	1750	60(30)	50	1	10	3/4	1	60	30	20.8
	15L	1750	60(30)	50	2	10	3/4	1	60	30	25.2

Table 2-5

Electrical Wiring Data for 575-Volt, 3-Phase, 60 Hertz Chempumps

Chempump Model	Motor Size	Full Load Speed (rpm)	Switch Size Amps	Breaker Size Amps	Starter NEMA Size	Conductor Size for Motor Leads	Conduit Size for Motor Leads Only	Conduit Size for Motor, PB & TCO Leads	Fuse Size Code and Current Limiting Amps	Fuse Size Dual Element Amps	Max. Setting of Time Limit Overload Protection Amps
GA, GB, GC, GVBS, GLD	1K	3450	30	15	0	14	1/2	3/4	15	3	2.2
	1-1/2K	3450	30	15	0	14	1/2	3/4	15	7	3.9
	3K	3450	30	20	1	14	1/2	3/4	20	15	6.4
GB, GC, GVBS, GLD	5K	3450	30(15)	20	1	14	1/2	3/4	25	12	8.75
GD, GE, GG, GFD, GVD, GVE	5K	3450	30	30	2	12	1/2	3/4	30	15	11.6
GD, GE, GG, GFD, GHD, GVD, GVE, GVH(S)	7-1/2K	3450	60(30)	40	2	12	1/2	3/4	40	20	16.1
	10K	3450	100	50	3	10	3/4	1	60	35	21.7
	15K	3450	100(60)	70	3	6	1	1-1/4	80	40	28.0
	20K	3450	100(60)	100	3	6	1	1-1/4	90	45	37.7
GVM (1150 rpm)	5P	1150	30	20	1	12	1/2	3/4	25	15	9.8
GVM (1750 rpm)	7-1/2L	1750	30	30	1	12	1/2	3/4	30	15	10.5
	10L	1750	60(30)	40	1	12	1/2	3/4	45	20	16.8
	15L	1750	60(30)	50	2	10	3/4	1	60	30	21.0

2-3,4. Oil Filled Stator

In order to facilitate the dissipation of heat from the motor section, the stator cavity on all Series G Chempumps are filled at the factory with a heat conductive dielectric oil. This oil filling provides better conductivity and allows the heat generated in the motor section to be conducted to the outside of the unit, thereby maintaining a lower temperature in the motor section than would be possible if the stator cavity were not oil filled.

When storing or installing oil filled stators, be sure that the motor lead or connection box nipple is maintained in an upright vertical position. This nipple is furnished with a special potting compound designed to minimize leakage of oil through the nipple, but wicking of oil through the lead wires can occur if the stator is laid on its side for any length of time. Should this happen, however, there is no need for alarm. Chempumps are designed to give long, trouble-free service without having their stator cavities oil filled. However, it has been proven that oil filling definitely extends the effective life of Chempump motor windings.

Oil relief valves are provided on all Chempumps having oil-filled stators, and are furnished with a combination breather and flame arrestor. The relief valve is preset at the factory to relieve at pressures of 17 psi or greater.

If a volume of oil in excess of that recommended is put in the stator section, the increased stator temperature which results from the pump being in operation will expand the oil, and the excess oil will be released through the oil relief valve. This emission of oil is in no way harmful to the operation of the unit. In subsequent operation of a unit, further, very small emissions of oil may be released through the relief valve if the temperature inside the stator cavity increases for some reason. Here again, there is no cause for alarm. See Table 2-6 for oil volume in Chempump stators, Page 12.

Table 2-6

Oil Volume In Chempump Stators

Model	Motor Size	Volume of Oil (Fluid Ounces)
GA	1K	20
GA, GB, GC	1-½	30
GB, GC, GVBS, GLD	3K	30
GB, GC, GVBS, GLD	5K	30
GD, GE, GFD, GVD, GVE	5K	70
GD, GE, GFD, GVD, GVE, GVH(S)	7-½K	70
GD, GVD, GVE, GVH(S), GE, GG, GFD, GHD	10K	70
GD, GVD, GVE, GVH(S), GE, GG, GFD, GHD	15K	70
GVD, GVE, GVH(S), GE, GG, GHD	20K	70
GVM	5P, 7-½L	95
	10L	95
	15L	95

2-4. Special Conditions and Features

2-4,1. Backflushing

For normal clear fluid applications, Series G Chempumps are cooled and lubricated by the fluid being pumped. For slurry or other "dirty" applications, a system of back flushing is recommended. Back flushing is noted on the order when recommended. See Figure 2-5 for typical back flush installation, Page 12.

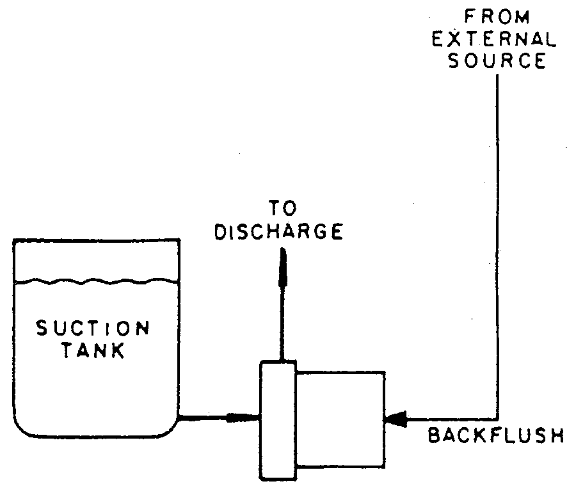


Figure 2-5 Back Flush System

Chempumps to be used with a back flush are normally supplied without circulating tubes. Clear fluid is brought to the fitting at the rear of the motor section by customer's piping as shown in Figure 2-5, Page 12. The amount of clear base fluid introduced in this manner should approximate the standard flow rates listed in Table 2-7, Page 12.

Table 2-7

Standard Recirculation Flow Rates

Model	Recirculation Flow Rate (gpm)
GA	1-2
GB	1 ½-2 ½
GVBS	1 ½-2 ½
GLD	1 ½-2 ½
GC	1-2
GD	1-3
GE,GVD,GVE,GVH(S)	2-4
GG	3-4
GVM	1-3
GFD	4-5
GHD	5-6

Back flush pressure should be suction pressure plus 20-30% of the pressure developed by the pump itself for single stage Models GA, GB, GC, GD, GE, GG, GVM, GVBS, GVD, GVE, GVH(S), and suction pressure plus 60-80% of the pressure developed by the pump itself for two stage Models GFD, GHD and GLD. Excessive back flush pressure will destroy the thrust balanced operation built into Series G Chempumps by causing excessive forward thrust.

Procedure:

1. Remove the circulating tube and plug off the port in the discharge neck of the pump casing used for the circulating tube front fitting. (This is done at the factory.)
2. Pipe in the clear liquid to the port in the rear bearing housing used for the circulating tube rear fitting. See Table 2-8 for proper circulating tube sizes, Page 13.
3. If the back flushing liquid is hot, auxiliary cooling methods, such as water jacketing the stator must be employed. The temperature of the back flush fluid should not exceed the fluid temperature limit of the unit installed. (180°F for Class A and B insulation; 400°F for Class H insulation.)

Table 2-8

Circulating Tube Sizes

Model	Tube Size
GA, GB, GC, GFD, GHD, GLD, GVBS, GVH(S)	¼" O.D. x .035 wall
GD, GE, GG, GVM, GVD, GVE	⅜" O.D. x .035 wall

2-4,2. Reverse Circulation

For normal clear fluid applications, Series G Chempumps are cooled and lubricated by the fluid being pumped, which flows through the circulating tube, into the rear of the rotor chamber, across the rear bearing, rotor, and front bearing, and then back into the main pumped stream through small holes provided in the rear of the impeller in the suction area. However, when the fluid being pumped is at or near its vapor pressure and the additional heat picked up from the motor, combined with the psia at the impeller suction could cause vaporization, the reverse circulation method of lubricating the bearings and cooling the motor should be used. Flow rates should duplicate those shown on Table 7.

Procedure:

1. Connect tubing (preferably ½" tubing at least) to the circulating tube port in the rear bearing housing.
2. Run the tubing from the connection port fitting in the rear bearing housing back to the suction receiver, preferably above the liquid level.
3. Use large size suction line and gate valve for low pressure drop and thus improve Available NPSH.

With reverse circulation, the rotor chamber will be under discharge pressure, with cooling fluid circulating from the pump end, through the rotor chamber, out the rear bearing housing and back to the suction vessel. Flow through stator-rotor cavity must be controlled to allow for good balance of pressure and temperature without excessive flow. See Figure 2-6, Page 13 for a typical reverse circulation installation. When provided, the reverse circulation modification is noted on the order.

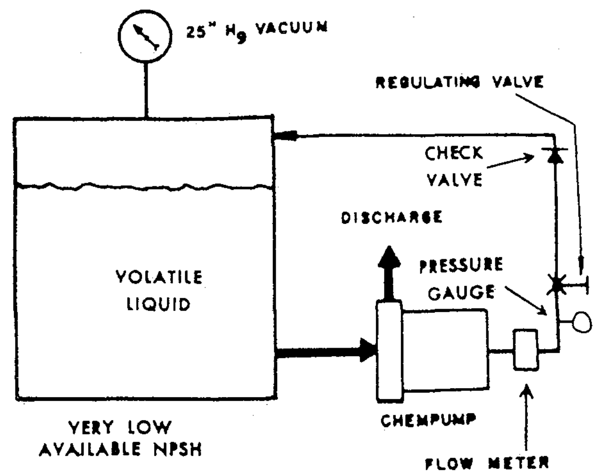


Figure 2-6 Reverse Circulation System

2-4,3. Electrical Isolation

To eliminate electrolytic corrosion when handling solutions during an electrolysis or plating operation, Chempumps should be electrically isolated. Insulated couplings or non-conductive plastic piping must be used in the primary suction and discharge lines. The Chempump must be isolated electrically from the tank, and separately grounded as shown in Figure 2-7, Page 13.

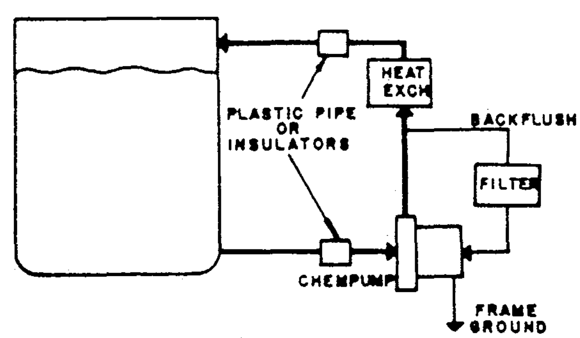


Figure 2-7 Back Flush Installation with Electrical Isolation

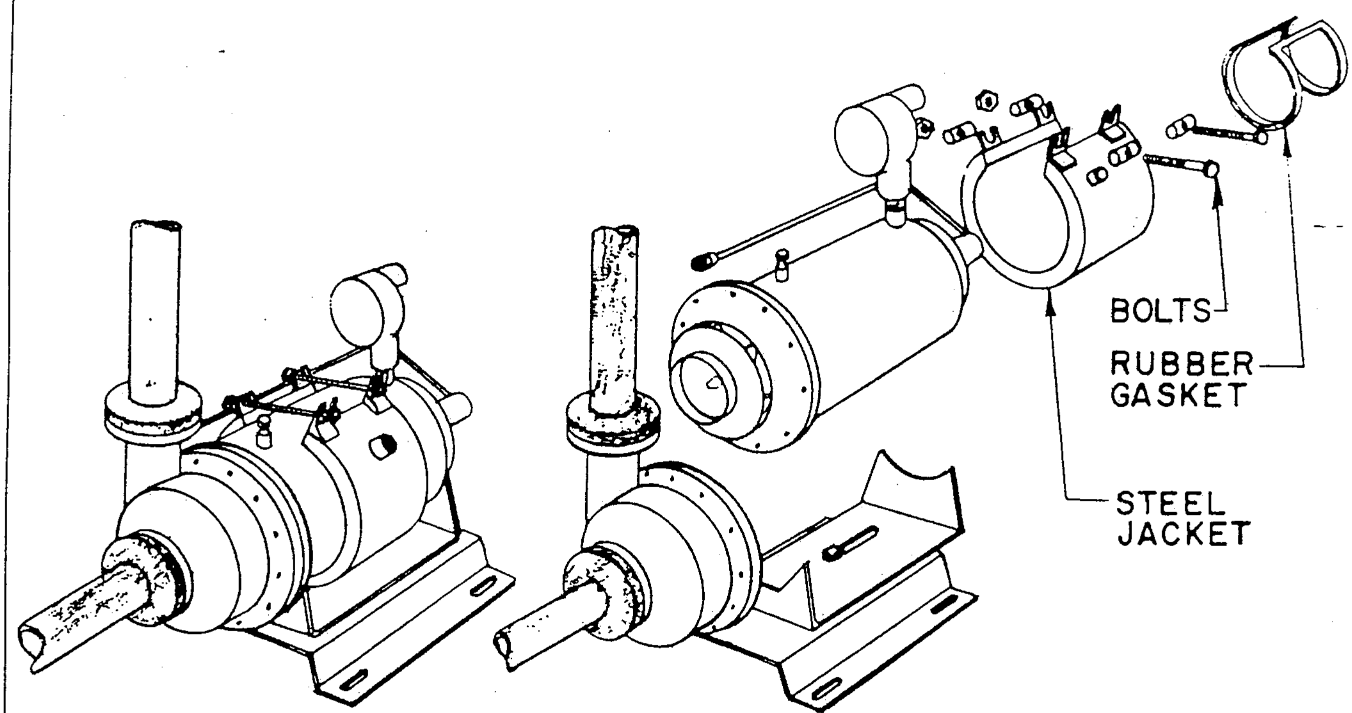


Figure 2-8 Removable Water Jacket

2-4,4. Water and Steam Jackets

When handling fluids at controlled temperatures, additional motor cooling or heating must be provided. For temperature control, steel jackets are provided for water, steam or other heat transfer media. Occasionally the pump can be submerged into the pumped fluid, thus providing an additional means of temperature control.

All Series G Chempumps can be provided with removable type water jackets when specified. (See Figure 2-8, Page 14.) This type jacket is easily removable from the stator band to allow for inspection and possible replacement. Removable type water jacket kits are available from the factory for provision on Chempumps already installed in the field when additional stator cooling is required. These jackets are suitable only for heating mediums compatible with the gasket and jacket material, with maximum inlet pressure of 50 psi and with maximum temperature of 150°F. They should not be used as steam jackets. Jackets welded to the stator band are available for use as steam jackets and for liquid mediums which exceed the temperatures and pressures noted above. Normally welded type jackets are suitable for steam pressures to 50 psi and liquid medium pressures to 100 psi. However, welded type jackets specially fabricated are also available for higher pressures. Removable or welded type heat exchanger jackets are recommended when handling liquids with low specific heat characteristics.

In addition to the above, special jackets are also available to completely enclose the motor section, circulating tubes and pump casing. Special pumps can be fitted with thermal sensing probes which provide high and low temperature cut off.

2-4,5. Heat Exchanger

Similar to the water jacket in every respect except for the provision of corrosion resistant tubing, heat exchangers, whether removable, wrap around or welded-on, are provided on Chempumps in applications that require heating or cooling the fluid before it enters the rotor chamber. Heat exchangers are especially recommended for liquids with low specific heat characteristics.

Models GA, GB, GC, GVBS, and GLD can be provided with removable wrap-around heat exchangers when specified. This type jacket is easily removable from the stator band to allow for inspection and possible replacement. These heat exchangers are suitable for maximum inlet pressure of 50 psi and maximum temperature of 150°F. (See Figure 2-9, Page 15.)

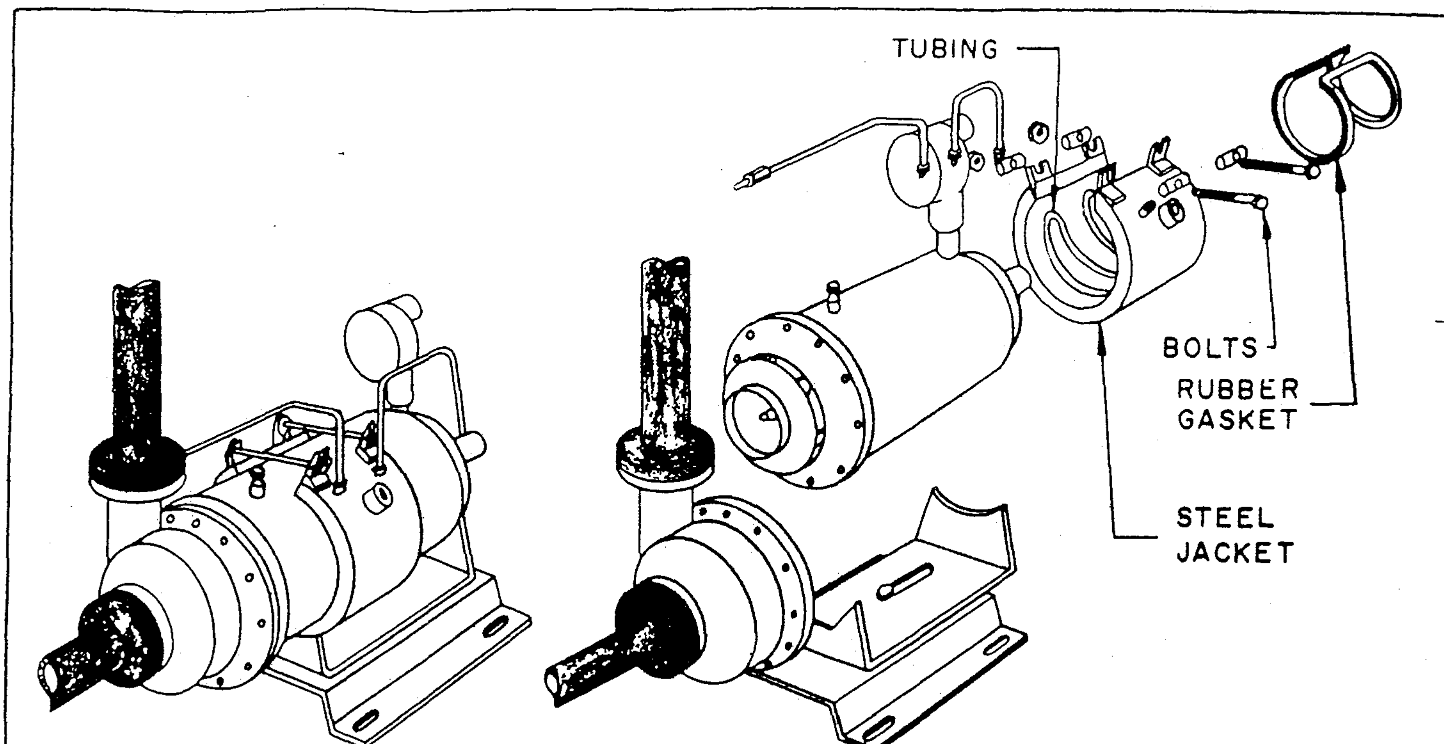


Figure 2-9 Removable Heat Exchanger

Models GD, GE, GG, GFD, GHD, GLD, GVM, GVBS, GVD, GVE and GVH(S) are available only with welded-on heat exchangers when specified. These heat exchangers are suitable for maximum inlet pressure of 100 psi, where maximum temperatures vary depending upon existing motor insulation and TCO setting as indicated on the pump nameplate.

2-4,6. Jacketed Circulation Tube

The jacketed circulation tube acts as a heat exchanger, in that it permits a heat transfer medium to circulate around the tubing and heat or cool the fluid before it enters the rotor chamber. The jacketed circulation tube is suitable for maximum inlet pressures of 50 psi liquid, or 15 psi steam. Higher pressures on special models. (See Figure 2-10, Page 15.)

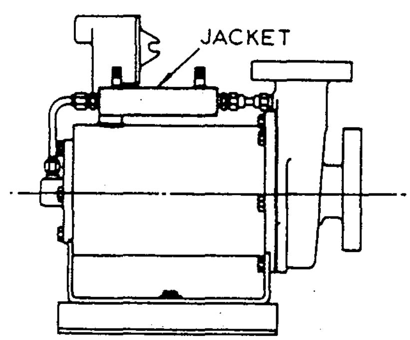


Figure 2-10 Jacketed Circulation Tube

2-4,7. High Pressure Lead Connector

The high pressure lead connector is provided as a standard item for Chempumps in 600 psi design and above. Usually, these high pressure pumps are not furnished with an oil relief valve since the high pressure lead connector can contain up to 5000 psi and since the stator pressure boundary walls are designed to contain the design pressure while the relief valve contains pressure to only 17 psi.

Since the high pressure lead connector can only be produced with single voltage motor leads, the customer must specify his single voltage requirement as 230 or 460 or 575, or other.

In the event of a stator liner rupture, this device eliminates the possibility of the pumped fluid escaping outside the unit or into the conduit line.

The high pressure lead connector can be supplied on 150 and 300 psi design pumps when specified; however, for maximum protection the standard nipple and connector require special threading and welding. (See Figure 2-11, Page 15.)

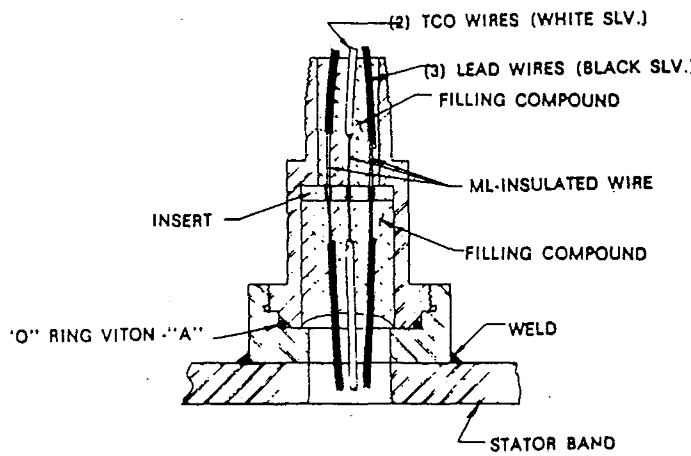


Figure 2-11 High Pressure Lead Connector

2-4,8. Leakproof Junction Box

The leakproof junction box is available on all Chempumps to 600 psi. Its purpose is to prevent fluid from seeping into the conduit line in the event of a stator liner rupture. Since it is wired for single voltage use, customer's voltage requirement must be specified when ordering. The leakproof junction box can be converted for use with alternate voltage by reconnecting the motor leads as indicated on the nameplate.

Screw-type connections permit easy field installation on existing stator nipple. (See Figure 2-12, Page 16)

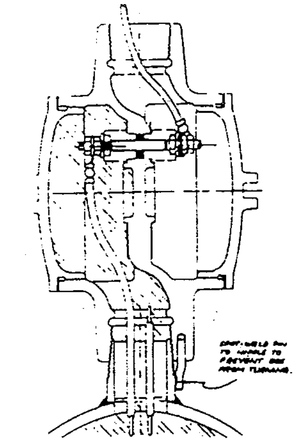


Figure 2-12. Leakproof Junction Box

SERIES G CHEMPUMP
INSTRUCTION MANUAL

SECTION 3. Operation

3-1. Procedure Before Initial Start-up

Before starting the pump for the first time, make sure suction and discharge piping are free of tools, nuts, bolts, or other foreign matter. Save time and money by checking before startup.

RECOMMENDED: Install a temporary 3/16" mesh screen near the suction port to trap scale and other foreign particles. Keep the screen installed for at least 24 hours of operation, but watch closely that the pump does not become starved for fluid because of a clogged screen. *Remove screen after 24 hours of running.*

3-2. Priming and Venting

The pump must be primed before operating. Priming requires the filling of the pump casing, rotor chamber and circulation tube with system fluid.

When there is a positive suction head on the pump, priming can be accomplished by opening the valves in the suction and discharge line, removing the vent plugs, and allowing the pump casing, rotor chamber, and circulation tube to fill. Air trapped in the unit will be displaced out through the vent holes.

3-3. Rotation Check

Centrifugal pump impellers must rotate in the proper direction to deliver rated head and capacity. The impeller must rotate in the same direction as the arrow cast in the pump casing. This can be checked as follows:

1. Wire Chempump motor for correct voltage (high or low) as shown on the nameplate. (See Paragraph 2-3, starting on Page 7.)

2. With main power leads connected, check direction of impeller rotation. If direction of impeller rotation is incorrect, change two power leads. Impeller rotation can be checked by one of two ways:

   a) After the Chempump has been installed and **primed,** use a phase sequence meter on the electrical connections. The readings from the phase sequence meter, which is relatively inexpensive and is available from a number of manufacturers, can be checked against the phase sequence indicated on the Chempump nameplate.

   b) After the Chempump is properly primed and vented, start the unit with the discharge valve closed and note the discharge pressure at a pressure gauge which is recommended to be installed immediately beyond the pump casing discharge flange. Reverse any two leads and read the pressure gauge again. The higher pressure is the correct direction of rotation. It is recommended that the unit be run as little as possible with a closed discharge valve in order to prevent excessive overheating of the fluid circulating within the unit.

NOTE

This method will not work without the discharge and suction gauge close to the pump. If a discharge valve is not available and the system head is mostly static, the lift reading will be the same in both directions. An alternate method is to use a discharge valve and a discharge pressure gauge and run the unit in both directions to determine higher head. Or, use a flow meter and determine higher flow rate or where head is mostly friction, higher discharge pressure reading will indicate proper direction.

Wrong direction of rotation is indicated by a low discharge pressure. At shut-off, head is about ⅔ of the head produced by correct rotation. Continued operation in reverse can result in the impeller's becoming loose or completely detached from the rotor shaft. If reverse rotation has occurred, it is wise to shut down and tighten the impeller nut before correct start-up.

3. Tag correctly connected main power leads 1-2-3, in accordance with motor lead markings.

3-4. Starting Procedure

After priming and checking the direction of rotation, put the pump in operation as follows:

1. Close the valve in the discharge line
2. Open the valve in the suction line, if closed
3. Start the pump
4. When the pump is running at full speed, open the valve in the discharge line slowly.

CAUTION

The pump should not be allowed to run for more than one minute with the discharge valve fully closed.

NOTES

1. If the suction and discharge lines are constantly filled with system fluid and the suction and discharge valves are open, the pump can be started without closing the discharge valve.
2. If the unit has not been run for a period of two weeks or more, the following inspections shall precede its operation:
   a) Check secureness of base holddown bolts if supplied.
   b) Check terminal box for moisture and tightness of fittings.
   c) Upon starting, check for excessive noise, vibration, or erratic speeds.

CAUTION

If the pump appears to be airbound as a result of the unit not being properly primed, do not continue operation. Locate and correct the conditions that prevent proper priming before attempting to start the unit.

3-5. Operation Details

Discharge pressure should be checked frequently during operation. Pressure should be stable in a non-variable closed loop although the discharge pressure gauge needle may show small fluctuations.

In some cases, the fluid supply may contain an excessive amount of air or gas which will tend to separate from the fluid and remain in the passage of the pump. This results in the pump losing its prime and becoming airbound with a marked reduction in capacity. The discharge pressure gauge may also show large fluctuations.

This condition can be alleviated by cracking the vent plug on the pump casing or rear bearing retainer while the pump is in operation.

3-6. Shutdown Procedure

Shutdown as follows:

1. Close the valve in the discharge line
2. Stop the pump. (De-energize the motor)
3. Close suction valves if pump is to be removed from service.

CAUTION

If the pump is to be shut down for a long period of time or if there is danger of freezing, stop pump, shut all suction and discharge valves, and drain the entire pump and connection piping.

SECTION 4. Maintenance

NOTE

To assist in determining remedies for various problems, see Table 4-3 Trouble Shooting, Pages 20 and 21.

4-1. Periodic Inspection

Initial inspection of the unit must be made at 1500 running hours or three months, whichever occurs first after initial starting. Subsequent inspection periods will be dependent on the wear rate as indicated in the following Paragraph 4-1-2, but in no case should any inspection period extend beyond three years. Each inspection should include attention to the points noted in each of the following paragraphs.

4-1,1. Recommended Tools

1. Dial Indicator (.200" travel) for determining end play.
2. Verniers and 5/16"-to-3" telescopic gauges for inspection of bearings, I.D. shaft clearance hole, and O.D. of rotor shaft journals.

4-1,2. Bearing Inspection

Since the bearings in this pump are basically sleeve type bearings, it is essential that bearing inspection and replacement periods be based on experience in each particular installation. Bearing life will depend, to some extent, on variable factors including lubrication quality, temperature, number of starts and stops, viscosity, and suspension content of the fluid being pumped, as well as ambient temperature and atmospheric conditions of the operational area. Each time one of these factors is changed, compensation must be applied in bearing inspectional periods.

As noted above, initial inspection of the bearings must be made at 1500 running hours, or three months, whichever occurs first after initial starting. This inspection is necessary to determine the rate of bearing wear, thereby enabling the setting up of a proper inspection and replacement schedule. See Table 4-1 for the maxinum wear allowable, Page 18.

If the inspection indicates that bearings are not wearing or are wearing very slightly, the next inspection may be put off for an additional 1500 running hours, or three months of operation, whichever occurs first. If inspection, then, still indicates only slight wear, the interval may be lengthened.

If, however bearings must be changed at the initial inspection, they will need to be changed again in the time period which necessitated a change at the initial inspection, i.e., 1500 running hours.

Frequency of periodic bearing inspection can best be determined by experience, and from these inspections, the time for replacement can best be indicated.

Bearings can be inspected and replaced without removing the pump casing from the line. No main piping connections need be broken. (See Paragraph 4-4 Disassembly and Reassembly, starting on Page 21).

To test for bearing wear:

1. Measure the inside diameters of the front and rear bearings and compare with the diameter of the rotor shaft journal. If the difference in diameters is greater than that indicated in Table 4-1, Page 18, replace the bearings.
2. Inspect the thrust faces of the front and rear bearings. If any scoring wear is visualized, measure the length of the bearings. Replace the bearing if the measured length is less than that indicated in Table 4-1, Page 18.
3. Examine the bearings for any grooving or scoring, particularly on the inside diameter and thrust faces. The existence of grooving or scoring indicates the presence of solids or foreign matter in the system which should be eliminated prior to again beginning operation.

4-1,3. Rotor Assembly Inspection

The complete rotor assembly should be visually inspected for cracks, breaks, pitting, or corrosion which might destroy the effectiveness of the hermetically-sealed rotor end covers and sleeve.

The rotor assembly shaft should also be visually inspected at the bearing contact area for general appearance and uniform wear. Excessive undercutting, pitting, or scoring is cause for rotor replacement. Minimum allowable shaft diameter is noted in Table 4-1, Page 18.

Table 4-1
Bearing and Journal Dimensions

Model	Shaft Outside Dia. New	Bearings Inside Dia. New	Diametrical Clearance Bearings to Journals		Bearing Lengths (Inches)	
			New	Max. Allow	Front Bearing	Rear Bearing
GA, GB, GC, GVBS, GLD	0.9143"-0.9150"	0.9175"-0.9185"	.0025"-.0042"	.013"	1¾"	1¾"
GD, GE, GG, GFD, GHD, GVD, GVE, GVH(S)	1.1833"-1.1840"	1.1888"-1.1890"	.0048"-.0057"	.014"	4"	2"
GVM	1.4893"-1.4900"	1.4950"-1.4960"	.0050"-.0067"	.014"	4⅜"	3¼"

4-1,4. Automatic Thrust Balance and End Play Inspection

The provision of automatic thrust balance design in the Series G Chempump, with its close running seal faces and wearing rings to insure proper balance chamber pressures, requires that a close visual inspection be made of the impeller, front bearing housing, front bearing and front rotor end cover at the time bearing inspection is made.

During disassembly for bearing inspection, measure the unit end play as follows:

1. For all models, after removing the rear bearing housing from the unit and with all other parts in place, measure the total axial (front to back) movement of the shaft, or,
2. In the case of Models GA, GB, GC and GVBS only, after the unit has been separated from the pump casing, measure the total axial (front to back) movement of the impeller assembly.

If the measured end play somewhat exceeds end play (new) noted in Table 4-2, Page 19, then remove the impeller from the shaft and the bearings from within the rotor chamber, visually examine the impeller seal faces, front bearing housing seal face, and the front rotor end cover for noticeable wear; also measure the length of the front bearing (see Table 4-1, Page 18). (The rear bearing, because of its position, will not usually experience axial wear.) Should the front bearing length be somewhat below the unit when new dimension, replace with a new bearing and then calculate if the new bearing length will put end play back in tolerance. If end play still exceeds the maximum allowable, then the impeller or front bearing housing seal faces (and in the case of Models GD, GVD, GVE, GVH(S), and GHD the pump casing seal faces) must be worn beyond a tolerable limit and must be repaired or replaced. (It should be noted that under proper operating conditions, wear on these parts due to axial thrust forces will be negligible and will normally not, therefore, require replacement.) At the time the impeller seal face is inspected for wear, also visually inspect the wearing rings and front impeller hub for any noticeable signs of wear. If excessive grooving or scoring of the wear rings or impeller hub is noticed, the impeller must be replaced.

Table 4-2 Series G End Play

Model	Total End Play - New
GA,GB,GC,	.084"-.104
GD,GE	.101"-.137
GVE	.101"-.137
GVD,GVH(S)	.032"-.068
GG	.102"-.138
GFD,GHD	.120"-.189
GVM	.068"-.096
GVBS	.084"-.106
GLD	.067"-.073

4-1,5. Stator Assembly Inspection

The complete stator assembly should be visually inspected for cracks, breaks, pitting, or corrosion in the stator liner which might destroy the effectiveness of the barrier.

Inspect the wiring of the stator assembly by checking the visible portion of the connector leads for cracked, broken, or frayed insulation, then check the condition of the motor windings by taking resistance readings with an ohmeter and a megger. If the ohmeter readings are not within 20% of the values shown in Table 4-4, Page 25 the stator assembly must be replaced.

4-1,6. General Inspection

1. Inspect the impeller nut threads on the rotor shaft to insure they are not cut, pressed, or stripped. Models GA, GB, GC, GVBS, GLD have left-hand threads. Models GD, GE, GG, GFD, GHD, GVM, GVD, GVE, GVH(S) have right-hand threads.
2. Be sure that all mating faces are free of nicks and burrs so that they will present a smooth face, insuring a good seal. Clean off any traces of old gasket material.
3. Make sure all parts are clean. Inaccessible areas may be cleaned with a small brush or suitably pointed tool. The circulation line should be blown out with filtered, oil-free compressed air.

4-2. Lubrication

The Series G Chempump requires no external lubrication. Bearing surfaces and other parts are lubricated and cooled by the fluid being pumped.

4-3. Cooling

The motor rear bearing housing temperature is a direct indication of the efficiency of the cooling and lubrication functions of the fluid circulation through the motor section of the pump. If, at any time during operation, the rear bearing housing appears overheated, check the temperature of the fluid being pumped. Check rear bearing housing temperature with a thermocouple to assure that it does not exceed the pumped fluid temperature (assuming that no auxiliary means of cooling the recirculation flow is used such as heat exchangers, jacketed circulation tubes, etc.). Rear bearing housing temperature can also be checked by using a pyrometer or a standard thermometer, held against the retainer by putty.

If the fluid temperature is satisfactory, overheating is most probably caused by a restriction in the circulation tube. Shutdown pump, drain unit, remove the circulation tube and clean it with clean, oil-free, compressed air. If the unit still runs hot, or if tube was clear, disassemble unit and inspect.

CAUTION

Between cycles of pumping fluids which may solidify, such as caustic soda, flush the system with steam, water or the proper solvent to prevent the piping and internal passages of the pump from plugging up. Where the Chempump is fitted with a discharge filter, flush pump during off cycles and check discharge filter for plugging.

Table 4-3

Trouble Shooting

TROUBLE	CAUSE	REMEDY
I. Failure to Deliver Required Capacity	a. Pump not primed	a. Reprime pump in accordance with Paragraph 3-2, Page 16.
	b. Air leaks in suction piping	b. Locate leaks and eliminate.
	c. Motor not energized	c. Check motor wiring. See Paragraph 2-3 Electrical starting on Page 7.
	d. Motor windings burnt-out or grounded	d. Check electrical continuity of windings and if negative response, stator assembly needs to be replaced.
	e. Low suction head	e. Correct suction side of system to insure availability of design NPSH.
	f. Discharge head too high	f. Correct discharge side of system to insure proper operating conditions.
	g. Discharge valve closed or partially opened	g. Open discharge valve until rated discharge pressure is obtained.
	h. Impeller clogged	h. Remove obstructions in the impeller.
	i. Wrong direction of rotation	i. Reverse any two motor leads and check with phase sequence meter. See Paragraph 2-3 Electrical starting on Page 7.
	j. Damaged Impeller	j. Impeller must be replaced.
II. Insufficient Pressure	a. Pump not primed	a. Reprime pump in accordance with Paragraph 3-2, Page 16.
	b. Air leaks in suction piping	b. Locate leaks and eliminate.
	c. Motor not energized	c. Check motor wiring. See Paragraph 2-3 starting on Page 7.
	d. Motor windings burnt-out or grounded	d. Check electrical continuity of windings and if negative response, replace stator assembly.
	e. Low suction head	e. Correct suction side of system to insure availability of design NPSH.
	f. Discharge valve open too wide	f. Close down discharge valve until rated discharge pressure is obtained.
	g. Impeller clogged	g. Remove obstructions in the impeller.
	h. Wrong direction of rotation	h. Reverse any two motor leads and check with phase sequence meter. See Paragraph 2-3, starting on page 7.
	i. Damaged impeller	i. Impeller must be replaced.
III. Pump Loses Prime After Starting	a. Pump not properly primed at starting	a. Reprime pump in accordance with Paragraph 3-2, Page 16.
	b. Air leaks in suction piping	b. Locate leaks and correct.
	c. Air or gas in fluid	c. Locate source of gas or air entrainment and correct.
	d. Low suction head	d. Correct suction side of system to insure availability of design NPSH.
IV. Pump Takes Too Much Power	a. Shaft bent	a. Rotor assembly must be replaced.
	b. Rotating element binds	b. Replace bearings (see Paragraph 4-1-2, Page 18) as a result of excessive wear, or check for presence of foreign material in rotor chamber.
	c. Electrical short	c. Check electrical continuity of all phases of the motor winding and replace stator assembly if necessary.
	d. Wrong direction of rotation	d. Reverse any two motor leads and check with phase sequence meter. See Paragraph 2-3, starting on Page 7.

TROUBLE	CAUSE	REMEDY
V. Pump Vibrates	a. Foundation not sufficiently rigid b. Impeller partialy clogged, causing unbalance c. Shaft bent d. Worn bearings e. Rotating element rubbing stator liner	a. Tighten all bolts involved with the pump base and base supporting structure. b. Remove obstructions in the impeller. c. Replace rotor assembly or straighten shaft if bend is not too great. d. Replace bearings (see Paragraph 4-1-2, Page 18). e. Replace bearings (see Paragraph 4-1-2, Page 18) as a result of excessive wear or check for presence of foreign material in rotor chamber.
VI. Motor Running Hot	a. If jacketed, no coolant flow circulating through jacket b. Jacket clogged, preventing full circulation of coolant flow c. Motor operating at overload condition d. Plugged discharge filter (if pump is equipped with filter) e. Circulation tube crimped or bent	a. Turn on coolant flow. b. Shut down pump and flush jacket. (If jacket is removable type, remove from stator and flush.) c. Make sure pump is operating at design point and conditions specified when purchased. d. Remove pump from line and flush filter. e. Replace with new tube (same size).

4-4. Disassembly and Reassembly

4-4-1 MODELS GA, GB, GC, GVBS—1 to 5 Horse power—Recommended Tools for Disassembly.

Sizes (Inches)	Description
1/2 and 9/16	Open end, box end wrench for circulation tube fitting
9/16	Open end, box end wrench for pump casing bolts
5/8	Socket for impeller nut
1/2	Open end, box end wrench for rear bearing retainer bolts
5/32 and 3/16	Allen wrench for front bearing retainer screws
3/8	Open end, box end wrench for stator retaining screw (WHIZLOCK)
3/4	Open end, box end wrench for base cradle retaining bolt (WHIZLOCK)
5/8	Open end, box end wrench for relief valve top
7/16	Open end, box end wrench for pump casing drain plugs

4-4,2. Models GD, GE, GG, GVM, GVD, GVE, GVH(S), Recommended Tools for Disassembly

Sizes (Inches)	Description
5/8 and 11/16	Open end, box end wrench for circulation tube fitting
3/4	Open end, box end wrench for pump casing bolts
1-1/8	Socket for impeller nut
3/4	Open end, box end for rear bearing housing bolts.
5/32 Hexwrench	Socket flat head cap screws for front bearing housing retaining screws
3/8	Open end, box end wrench for stator assembly retaining screws (WHIZLOCK)
3/4	Open end, box end wrench for base cradle retaining bolt (WHIZLOCK)
5/8	Open end, box end wrench for relief valve top
9/16 and 5/8	Open end, box end wrench for pump casing drain plugs
1/8 Allenwrench or 7/16	Open end box end wrench for bearing assembly retainer screw

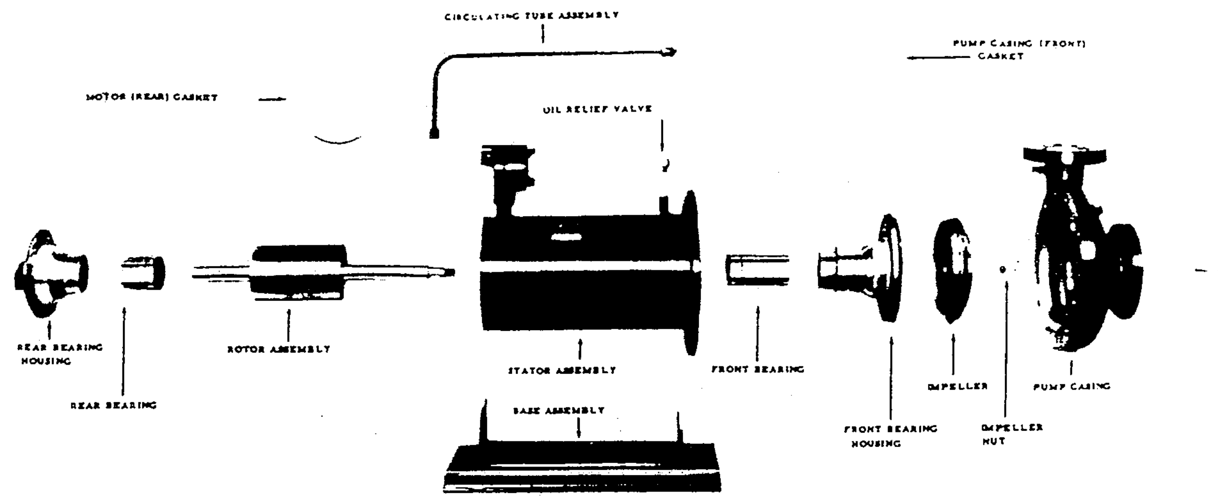


Figure 4-1 Exploded View
Models GA, GB, GC, GD, GE, GG, GVM, GVBS, GVD, GVE, GVH(S)

4-4,2,1. Models GA, GB, GC, GVBS, GD, GE, GG, GVE, GVD, GVH(S), GVM, Disassembly and Reassembly Procedure

1. Close discharge valve, shutdown pump, and then close the suction valve.
2. Drain Pump.
3. Begin disassembly, carefully examining each part for corrosion or wear.
4. Remove circulating tube, back flush piping, or reverse circulation piping if so equipped.
5. Remove water jacket cooling inlet and drain connections, if used.
6. Remove bolts holding rear bearing housing to stator assembly and then remove the housing.
7. Remove the screw and lockwasher holding the rear bearing to rear bearing housing, and then remove the rear bearing.
8. Check end play as indicated in Paragraph 4-1-4, Page 19.
9. Remove bolts holding motor section to pump casing.
10. a) If a base is provided, loosen one bolt and remove the other which holds together the upper and lower sections of the base assembly. Next, pull the motor section, resting on the upper half or cradle portion of the base assembly, away from the pump casing until the impeller hub is clear of the casing. Then, rotate the motor section and cradle to a point which will allow further disassembly of same. This specially constructed base, which is furnished as standard on all Series G Chempump models, allows inspection or maintenance to be performed on the unit without its having to be moved to a workbench or without the motor section having to be set on the floor or ground. If desired, the motor section can be removed from the lower base section and taken to another area for inspection. In this case, the upper half of the base is used as a stand to protect the parts.
    b) If a base is not supplied, remove the motor section and if necessary, disconnect the power cable from the connection box if the unit is to be taken to a workbench.
11. Remove the impeller nut (Models GA, GB, GC, GVBS have left hand thread; Models GD, GE, GG, GVM, GVD, GVE, GVH(S) have right hand thread.) Then remove the impeller.
12. Withdraw rotor assembly from rear of motor section, taking care not to allow rotor to drop, thereby allowing shaft to hit stator liner.
13. Remove the three screws retaining the front bearing housing to the stator assembly, and then remove the housing.
14. Remove the screw and lockwasher holding the front bearing to the front bearing housing and then remove the front bearing.
15. Check for bearing wear can be made at this time. See Paragraph 4-1-2, Page 18.
16. Reassemble pump by reversing disassembly procedure; replace old gaskets with new ones. BE SURE TO TAKE UP EVENLY ON BOLTS SECURING BEARING HOUSING. Otherwise, the housing may cock and misalignment will cause rapid bearing wear.
17. Complete reassembly. However, before bolting the motor section to the pump casing, spin the rotor impeller assembly by hand to insure that it does not bind. Also, check end play again as noted in Paragraph 4-1-4, Page 19 before reassembling the rear bearing housing to the stator assembly but

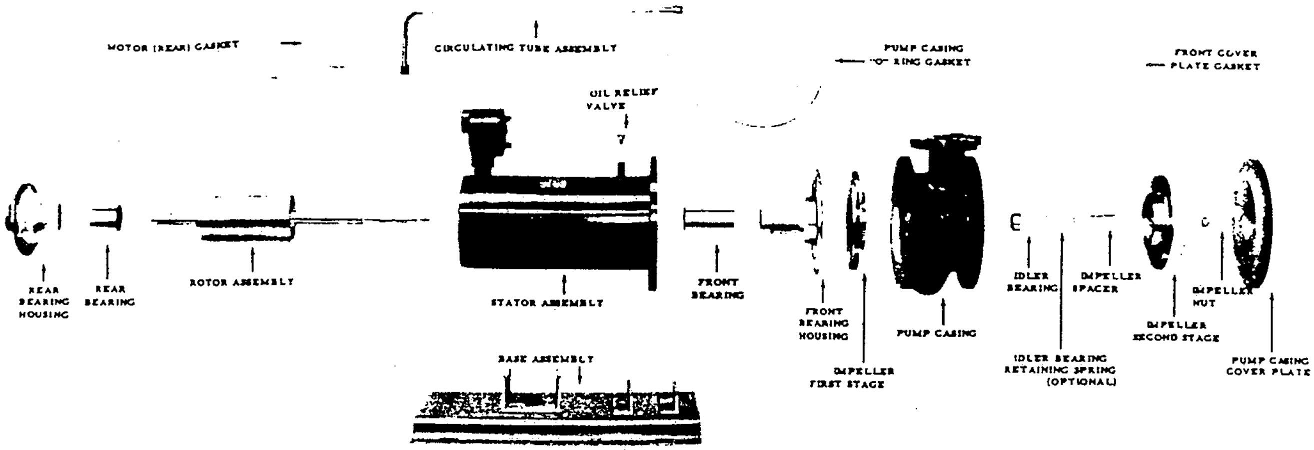


Figure 4-2 Exploded View Models GLD, GFD, GHD

after bolting the pump casing to the motor section.

18. In reassembling the impeller nut, care must be taken to completely tighten the impeller lock nut against the impeller to insure that it securely holds the impeller against the shaft shoulder.

4-4,3. Models GLD, GFD, GHD—5 to 20 Horsepower — Recommended Tools for Disassembly

Sizes (Inches)	Description
5/8 and 11/16	Open end, box end wrench for circulation tube fitting
3/4	Open end, box end wrench for pump casing bolts
1/2 Drive, 1 Socket	For impeller nut
3/4	Open end, box end for rear bearing housing bolts
5/32 Hexwrench	Socket flat head cap screws for front bearing housing retaining screws
3/8	Open end, box end wrench for stator retaining screws (WHIZLOCK)
3/4	Open end, box end wrench for base cradle retaining bolt (WHIZLOCK)
5/8	Open end, box end wrench for relief valve top
9/16 and 5/8	Open end, box end wrench for pump casing drain plugs.
7/16	Open end, box end wrench for bearing retainer screws

4-4-3-1. Models GFD, GHD, GLD Disassembly and Reassembly Procedure

Unlike the other Series G models covered by this manual, the Models GFD, GHD and GLD are two-stage models and as a result disassembly and reassembly instructions are a bit different. The step by step procedure is as follows:

1. Close discharge valve, shutdown pump, and then close the suction valve.
2. Drain pump.
3. Begin disassembly, carefully examining each part for evidence of corrosion or wear.
4. Remove circulating tube, back flush piping, or reverse circulation piping, if so equipped.
5. Remove water jacket cooling inlet and drain connections, if used.
6. Remove bolts holding rear bearing housing and then remove the housing.
7. Remove the screw and lockwasher holding the rear bearing to the rear bearing housing and then remove the rear bearing.
8. Check end play as indicated in Paragraph 4-1-4, Page 19.
9. Then, moving to the front of the unit, remove bolts holding pump casing cover plate to pump casing, and then remove cover.
10. Remove the exposed impeller nut and then the impeller, and key (second stage impeller). Second stage impeller has tapped pull holes for easy removal and for holding impeller when removing impeller nut.
11. Remove the spacer sleeve from the shaft.
12. Remove bolts holding motor section to pump casing.
13. a) If a base is provided, loosen one bolt and remove the other which holds together the upper and lower sections of the base assembly. Next, pull the motor section, resting on the upper half or cradle portion of the base assembly, away from the pump casing until the front end of the rotor shaft is clear of the casing. Then, rotate the motor section and cradle to a point which will allow further disassembly of the unit. This specially constructed base, which is furnished as standard on all Series G Chempump models, allows inspection or maintenance to be performed on the unit without its having to be removed to a workbench or without the motor section having to be set on the floor or ground.

If desired, the motor section can be removed from the lower base section and taken to another area for inspection. In this case, the upper half of the base is used as a standard to protect the parts.

b) If a base is not supplied, remove the motor section, and if necessary, disconnect the power cable from the connection box if the unit is to be taken to a workbench.

14. Slip off the first stage impeller and remove the key from the shaft.
15. Withdraw the rotor assembly from the rear of the motor section, taking care not to allow the rotor or shaft to hit the stator liner.
16. Remove the three screws retaining the front bearing housing to the stator assembly and then remove the housing.
17. Remove the screw and lockwasher holding the front bearing to the front bearing housing and then remove the bearing.
18. Slip out the idler bearing from the pump casing.
19. Check for bearing wear can be made at this point. See Paragraph 4-1-2, Page 18.
20. Reassemble pump by reversing the disassembly procedure, replacing old gaskets with new ones. BE SURE TO TAKE UP ON ALL BOLTS EVENLY. Otherwise, misalignment may occur, which would cause rapid bearing wear.
21. Complete reassembly. However, before bolting the pump casing cover plate to the pump casing, spin the rotor-impeller assembly by hand to insure that it does not bind. Also, check end play again as noted in Paragraph 4-1-4, Page 19 before reassembling the rear bearing housing to the stator assembly.
22. In reassembling the impeller nut, *care must be taken* to completely tighten the impeller lock nut against the impeller to insure that it securely holds the impeller against the shaft shoulder.

4-5. Service Policy

Any Chempump, damaged or inoperative for any reason, will be repaired at the factory at minimum cost and returned to the customer as quickly as possible.

CAUTION

Before returning units to the factory for examination or repair, CLEAN AND DECONTAMINATE THE PUMP OR PARTS THOROUGHLY TO PREVENT CORROSIVE ATTACK DURING SHIPMENT OR INJURY TO PERSONNEL HANDLING RETURNED EQUIPMENT. TAG PUMP WITH INFORMATION REGARDING THE FLUID IT WAS HANDLING AND OPERATING CONDITIONS AT THE TIME OF FAILURE. Proper service will be facilitated with the proper submittal of Chempump Field Service Report Form. These forms are available from the factory, from the Chempump field representatives, and from this instruction manual, Page 26.

4-6. Spare Parts

Have on hand at least two extra sets of bearings, two extra sets of gaskets, and one extra rotor assembly for each Series G Chempump that is installed. When ordering spare parts, give the serial number and model designation; then give the part name (which is noted on the Exploded View Parts—Pages 22, or 23) and material of the part.

When ordering an impeller, include the diameter which can be noted from the pump order acknowledgment or from the pump nameplate.

It is recommended that the following be maintained as "on-hand" spare parts for each Chempump model installed:

1. Models GA, GB, GC, GVBS

Part	Quantity
Pump Casing Gasket	2
Rear Motor Gasket	2
Front & Rear Bearings	2 sets
Rotor Assembly	1
Bearing Housing Screw	4
Bearing Housing Screw Lockwasher	4

2. Models GD, GE, GG, GVM, GVD, GVE, GVH(S)

Part	Quantity
Discharge Filter	1
Pump Casing Gasket	2
Rear Motor Gasket	2
Front & Rear Bearings	1 set
Impeller Nut	1
Impeller Key	1
Rotor Assembly	1
Bearing Housing Screw	4
Bearing Housing Screw Lockwasher	4

3. Models GLD, GFD, GHD

Part	Quantity
Discharge Filter	1
Coverplate Gasket	2
Pump Casing "O" Ring Gasket	2
Rear Motor Gasket	2
Front & Rear Bearings	1 set
Impeller Nut	1
Impeller Key	2
Idler Bearing	1
Impeller Spacer	1
Rotor Assembly	1
Bearing Housing Screw	4
Bearing Housing Screw Lockwasher	4

Table 4-4

COIL RESISTANCE VALUES

Model	Motor Size	Elect. Conn.	Insul. Class	Resis. (ohms)	Max. ohm Var. Per ϕ	Max. ohm Var. Per Motor
GA	1K	230	A	6.080	.07	± .13
	1K	230	H	7.77	.08	± .15
	1K	460	A	24.80	.20	± .4
	1K	460	H	26.98	.24	± .4
GA, GB, GC	1-1/2K	230	A	3.60	.05	± .1
	1-1/2K	230	H	4.42	.05	± .1
	1-1/2K	460	A	12.86	.15	± .3
	1-1/2K	460	H	13.59	.15	± .3
GB, GC, GVBS GLD	3K	230	H	1.77	.03	± .06
	3K	460	H	7.00	.07	± .14
	3K	230	A	1.56	.03	± .06
	3K	460	A	6.19	.06	± .12
	5K	230	A	1.03	.027	± .05
	5K	460	A	4.10	.05	± .1
	5K	230	H	1.08	.03	± .06
	5K	460	H	4.15	.05	± .1
GE, GD, GFD GVD, GVE, GVH(S)	5K	230	H	.90	.03	± .06
	5K	460	H	3.60	.05	± .1
	7-1/2K	230	H	.475	.02	± .04
	7-1/2K	460	H	1.90	.03	± .06
GE, GD, GG, GFD, GHD, GVD, GVE, GVH(S)	10K	230	H	.34	.015	± .03
	10K	460	H	1.43	.03	± .06
	15K	230	H	.29	.015	± .03
	15K	460	H	1.10	.03	± .06
	20K	230	H	.17	.015	± .03
	20K	460	H	.75	.03	± .06
GVM	5P	230	A	.81	.03	± .06
	5P	460	H	3.20	.05	± .1
	7-1/2L	230	A	.56	.03	± .06
	7-1/2L	460	H	2.58	.03	± .06
	10L	230	A	1.95	.03	± .06
	10L	460	H	1.98	.03	± .06
	15L	230	A	1.06	.03	± .06
	15L	460	H	1.26	.03	± .06

SAMPLE: TROUBLE ANALYSIS SHEET

CHEMPUMP DIVISION • CRANE CO DATE: ....

4.7 FIELD SERVICE REPORT:

CUSTOMER: .... REPRESENTATIVE ....

....

....

CHEMPUMP MODEL: .... S/N ....

Proper analysis of the trouble you have been experiencing requires an accurate description of operating conditions and the system in which the pump is installed.

Date Installed .... Removed .... Hrs. Used ....

1. **Liquid or Solution Handled** ....
(Include impurities or % if mixture)

Is dissolved gas present? ....

Are solids in suspension present? ....

If so, state nature ....

2. **Actual Operating Conditions** **Transfer** **Circulating**

(a) Flow .... GPM
(b) Suction Pressure .... Psig
(c) Disch. Pres. .... Psig
(d) Differential .... Psi/Ft.
(e) Pumping Temp. .... °F
(f) Sp.Gr. @ P.T. ....
(g) Viscosity At:
Pumping Temp. .... Cps
Ambient .... Cps
(h) Vapor Pressure At:
Pumping Temp. .... Psia/mmhg
Ambient .... Psia/mmhg

3. Please send a sketch of your system. Give a brief description—including a rough flow sheet. Indicate what chemical or physical action occurs before the pump. Show cooling or heating services on lines directly affecting the pump. Show what controls are used and what they operate. If more than one pump operates on a common suction, show how they are balanced.

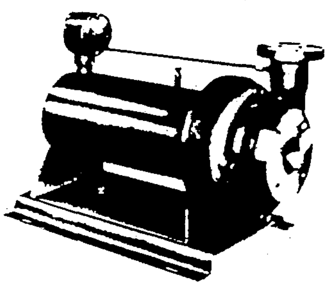
YOUR ATTENTION TO THIS REPORT IS GREATLY APPRECIATED. UPON RECEIPT OF IT AT CHEMPUMP DIVISION • CRANE CO., WARRINGTON INDUSTRIAL PARK, WARRINGTON, PENNSYLVANIA WE WILL EVALUATE THE FACTS SHOWN AND RETURN OUR RECOMMENDATIONS TO YOU.

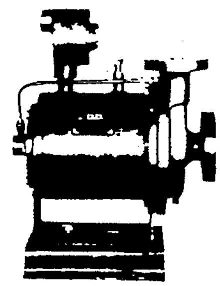
The Chempump Division of Crane Co. announces a new concept in pump repair...

CUSTOMER SERVICE CENTERS

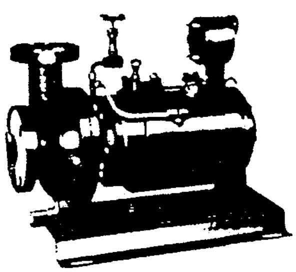
A National Program of factory owned and factory authorized repair centers in the most important and concentrated industrial manufacturing and process industry operations in the United States.
It's a *new* concept because . . .

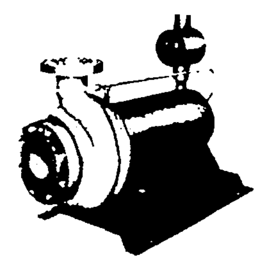
at every Customer Service Center





- Every pump repaired will receive a written analysis including the cause of failure and description of repair or replacement work done.
- Repair turn-around will average 48 hours on standard pumps.
- Generally all repairs will *not* exceed 80% of the cost of a new pump.
- Replaced parts carry a 1-year warranty.
- Repaired parts warranted for 90-days.
- A full inventory of stators, impellers, rotors, bearings and gaskets.





C.S.C. LOCATIONS READY FOR SERVICE

These C.S.C. locations will do all out-of-warranty repairs. Warranty repairs must go to Warrington, Pa.

1. **Bellmawr, New Jersey**—***Factory Owned***
   Phone: (609) 931-8200
2. **Eureka, West Virginia**—***Factory Authorized***—**Pittsburgh Process Machine & Repair**
   Phone: (304) 684-2459
3. **Houston, Texas**—***Factory Authorized***—**Texas Process Equipment Co.**
   Phone: (713) 460-5555

CRANE® **CHEMPUMP** Crane Co., Chempump Division, Warrington, PA. 18976

CHEMPUMP PERFORMANCE CURVES

MOTOR LOAD LINES ARE BASED ON OIL FILLED STATORS & MEET NEMA STD'S.

Curves are based on shop test while handling clear water at 20°C and at sea level. Performance guarantees apply at rating point only. Efficiencies shown are overall wire to water. Numbers beneath model designations indicate full load kilowatt ratings for the referenced motor load lines.

When pumping fluids with specific gravities other than 1.0, select pump model (see load line) to handle load equivalent in feet of water, e.g. 40 feet of fluid of Sp. Gr. 1.5 is load equivalent of 60 feet (1.5x40) of water. Please note that this is merely a short cut method to estimate the model required. For proper model selection, especially when handling a fluid with a Sp. Gr. greater than 1.7, consult your Chempump representative or the factory.

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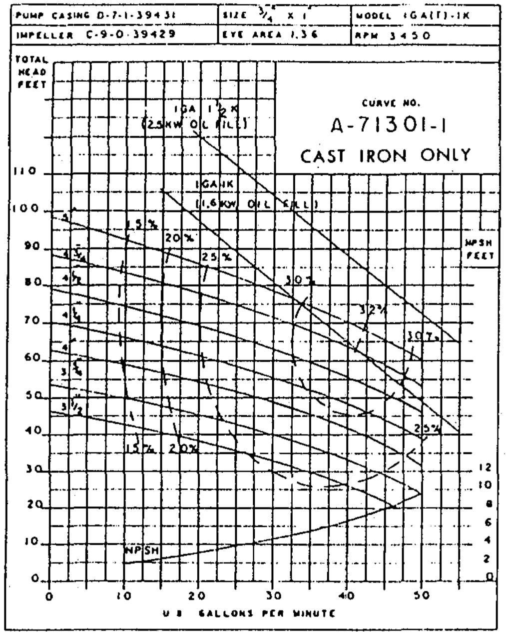
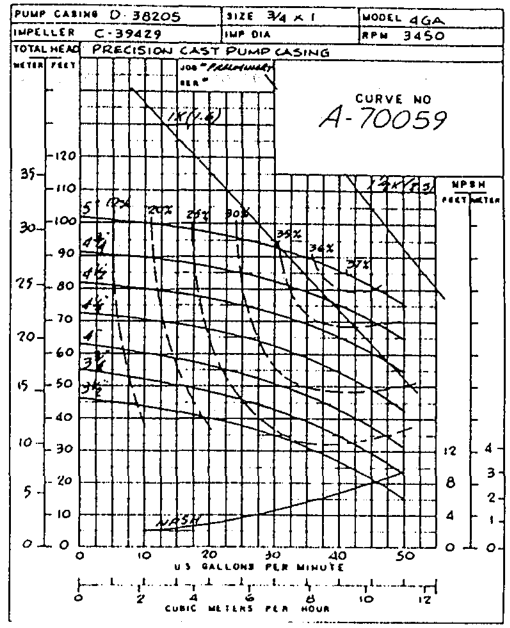
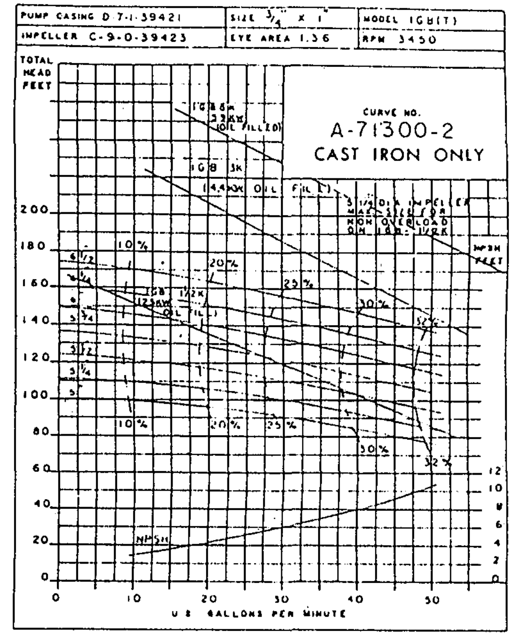
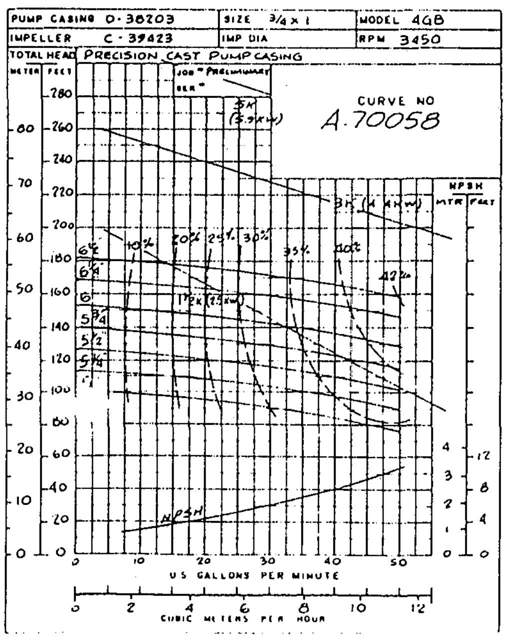
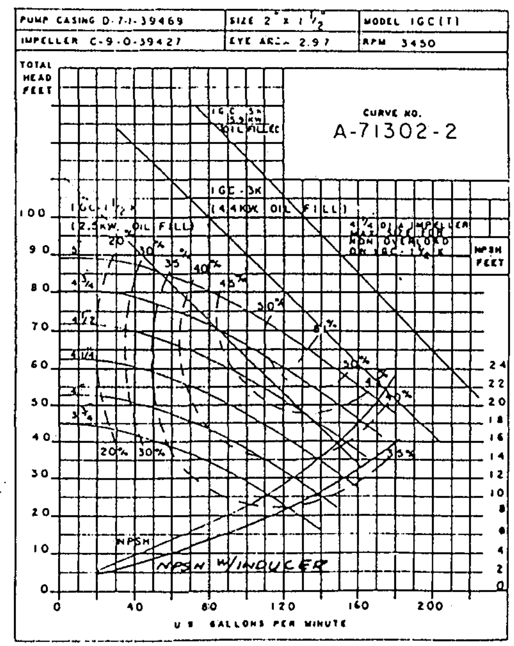
CHEMPUMP DIVISION
CRANE CO

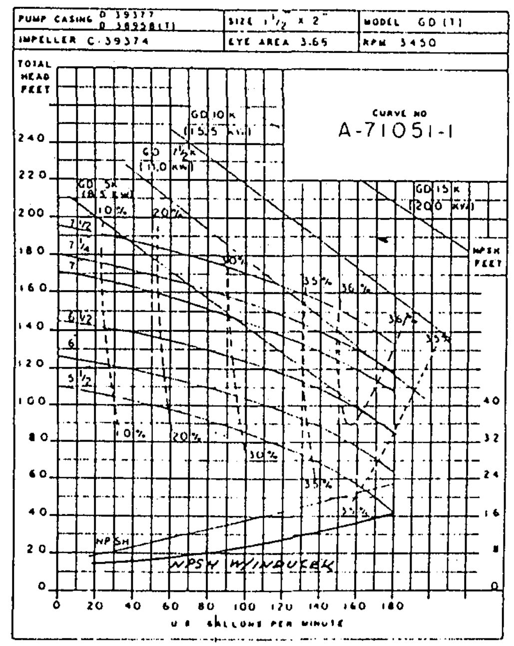












CHEMPUMP PERFORMANCE CURVES

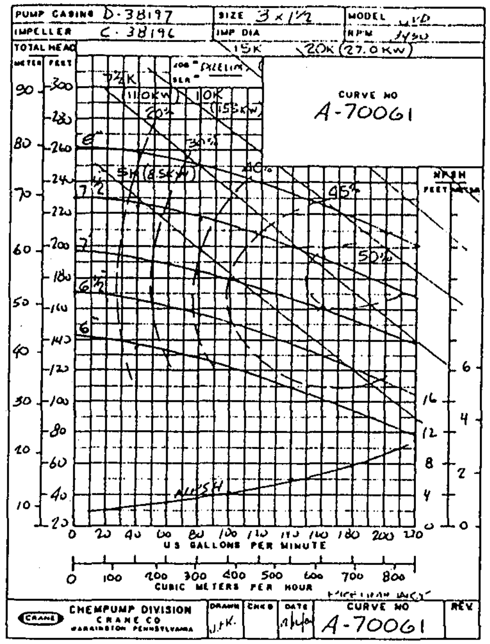
MOTOR LOAD LINES ARE BASED ON OIL FILLED STATORS & MEET NEMA STD'S.

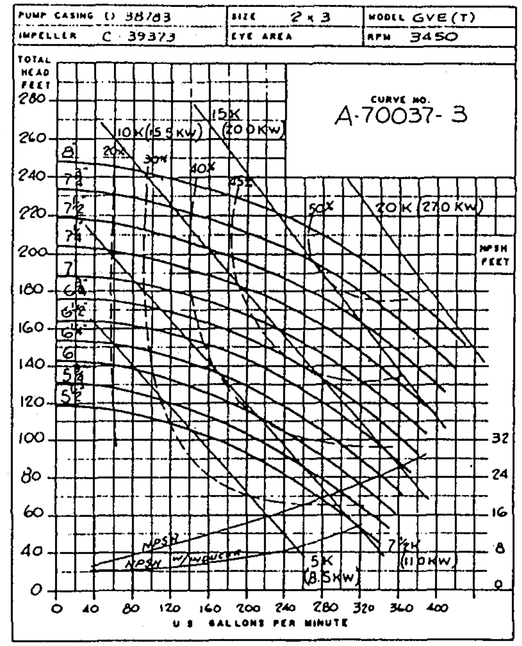
Curves are based on shop test while handling clear water at 20°C and at sea level. Performance guarantees apply at rating point only. Efficiencies shown are overall wire to water. Numbers beneath model designations indicate full load kilowatt ratings for the referenced motor load lines.

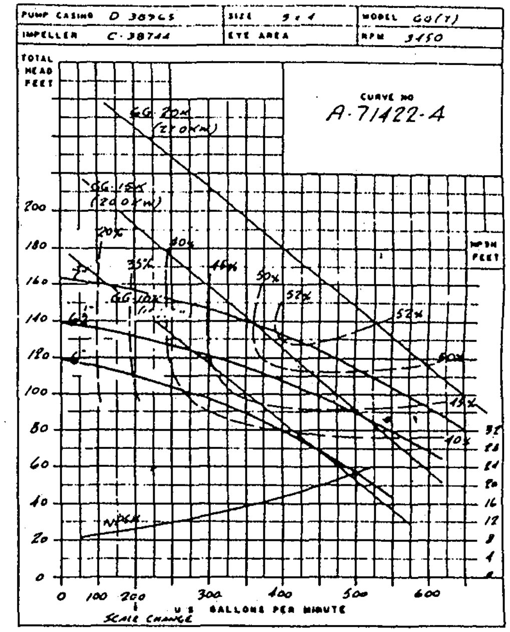
When pumping fluids with specific gravities other than 1.0, select pump model (see load line) to handle load equivalent in feet of water, e.g. 40 feet of fluid of Sp. Gr. 1.5 is load equivalent of 60 feet (1.5x40) of water. Please note that this is merely a short cut method to estimate the model required. For proper model selection, especially when handling a fluid with a Sp. Gr. greater than 1.7, consult your Chempump representative or the factory.

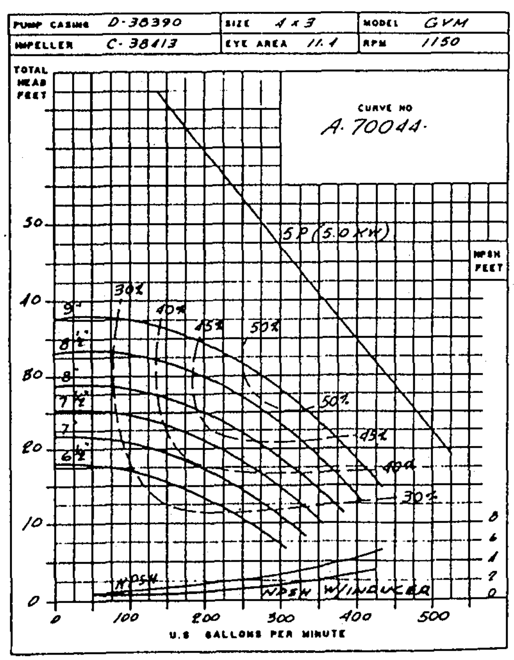
CRANE

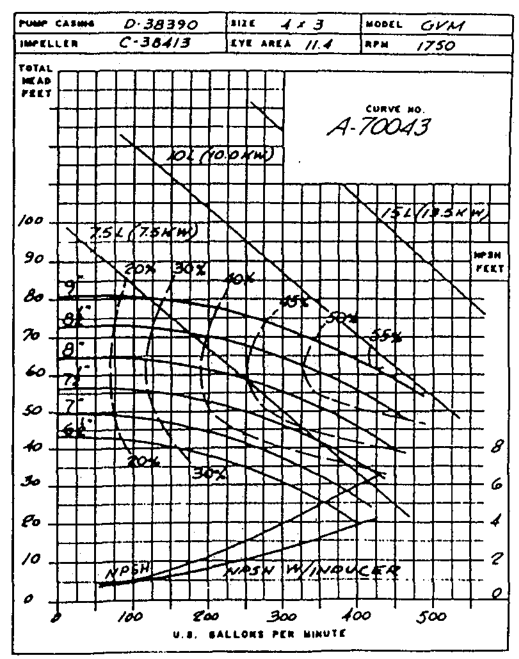
CHEMPUMP DIVISION
CRANE CO.
WARRINGTON INDUSTRIAL PARK
WARRINGTON, PA

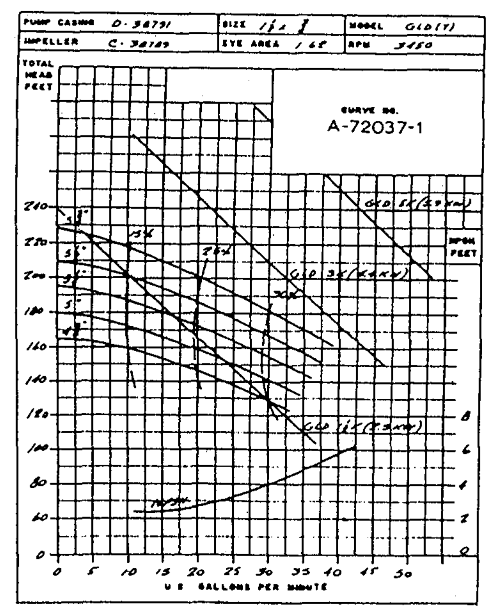












CHEMPUMP PERFORMANCE CURVES

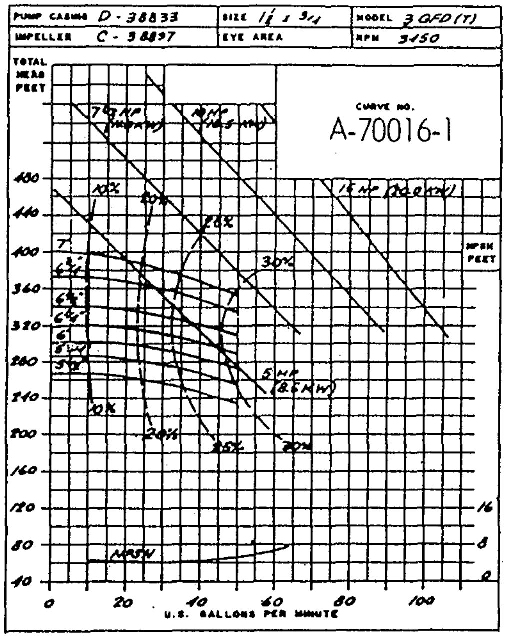
MOTOR LOAD LINES ARE BASED ON OIL FILLED STATORS & MEET NEMA STD'S.

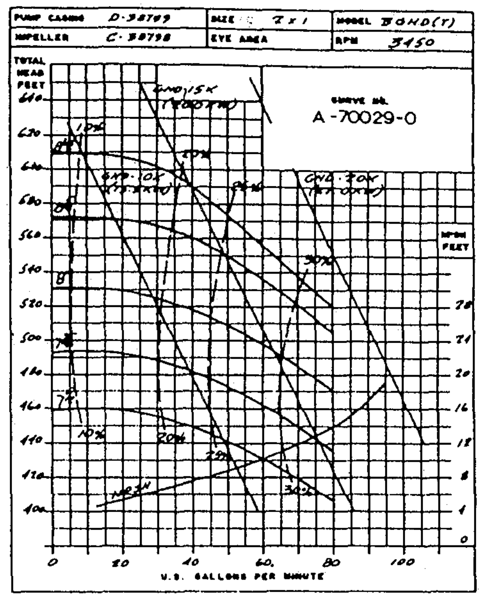
Curves are based on shop test while handling clear water at 20°C and at sea level. Performance guarantees apply at rating point only. Efficiencies shown are overall wire to water. Numbers beneath model designations indicate full load kilowatt ratings for the referenced motor load lines.

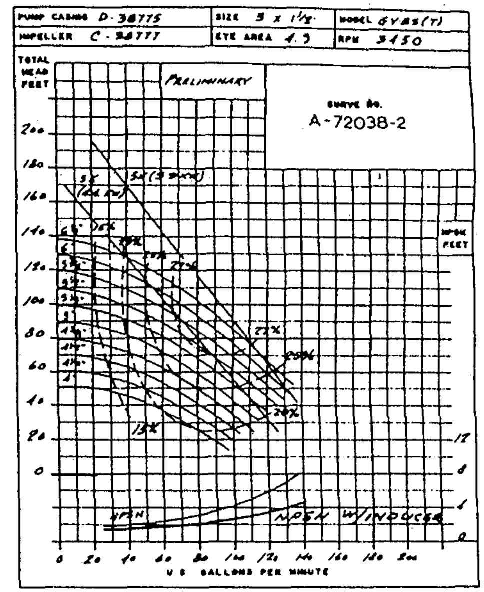
When pumping fluids with specific gravities other than 1.0, select pump model (see load line) to handle load equivalent in feet of water, e.g. 40 feet of fluid of Sp. Gr. 1.5 is load equivalent of 60 feet (1.5x40) of water. Please note that this is merely a short cut method to estimate the model required. For proper model selection, especially when handling a fluid with a Sp. Gr. greater than 1.7, consult your Chempump representative or the factory.

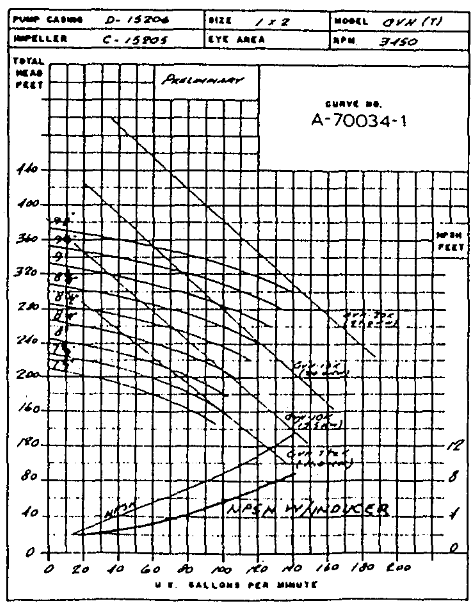
CRANE

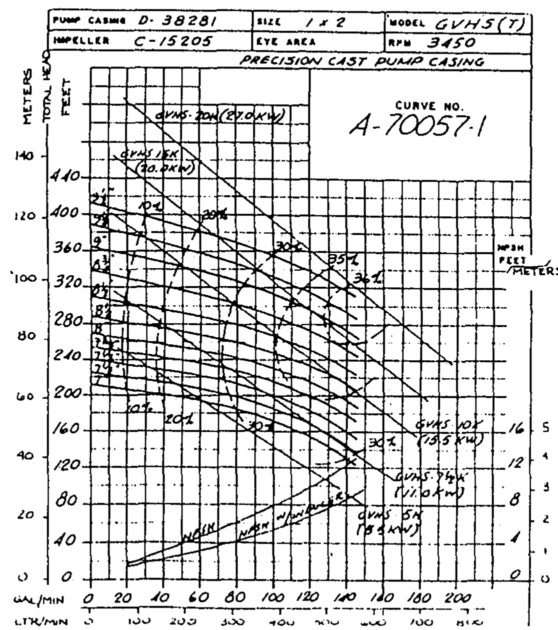
CHEMPUMP DIVISION
CRANE CO.

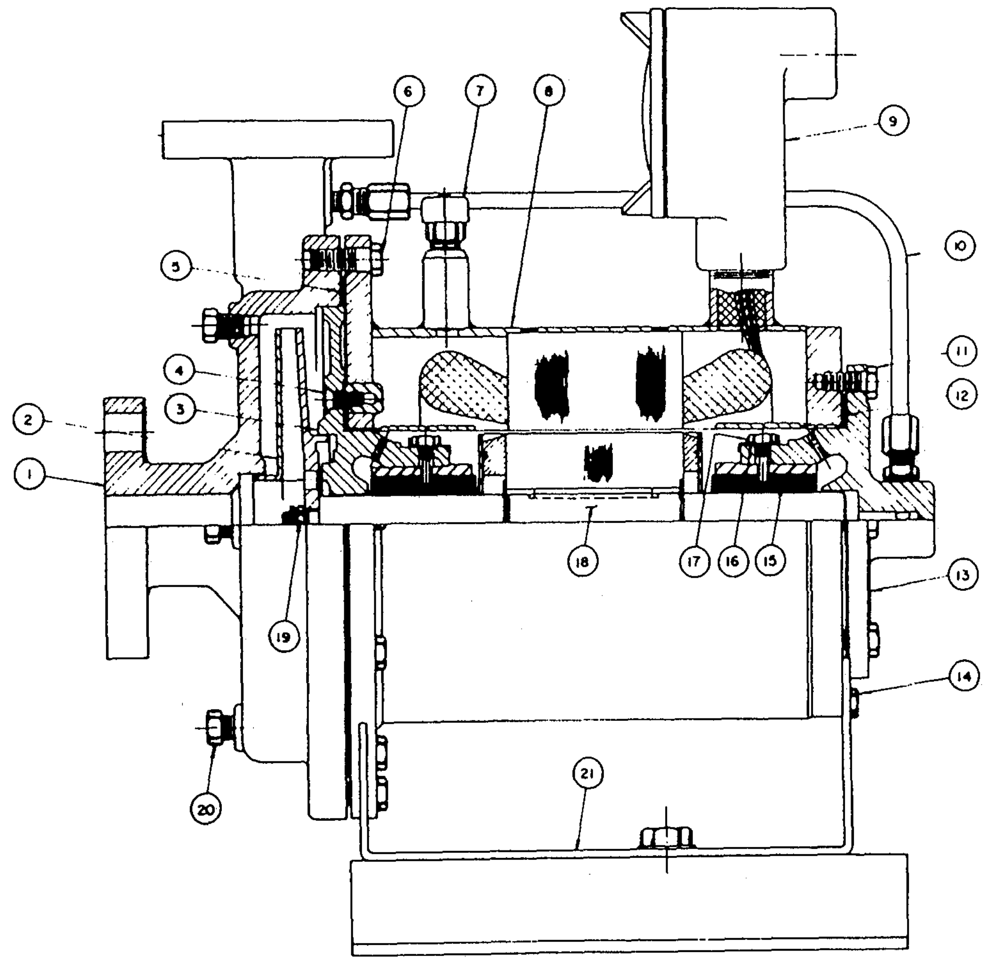












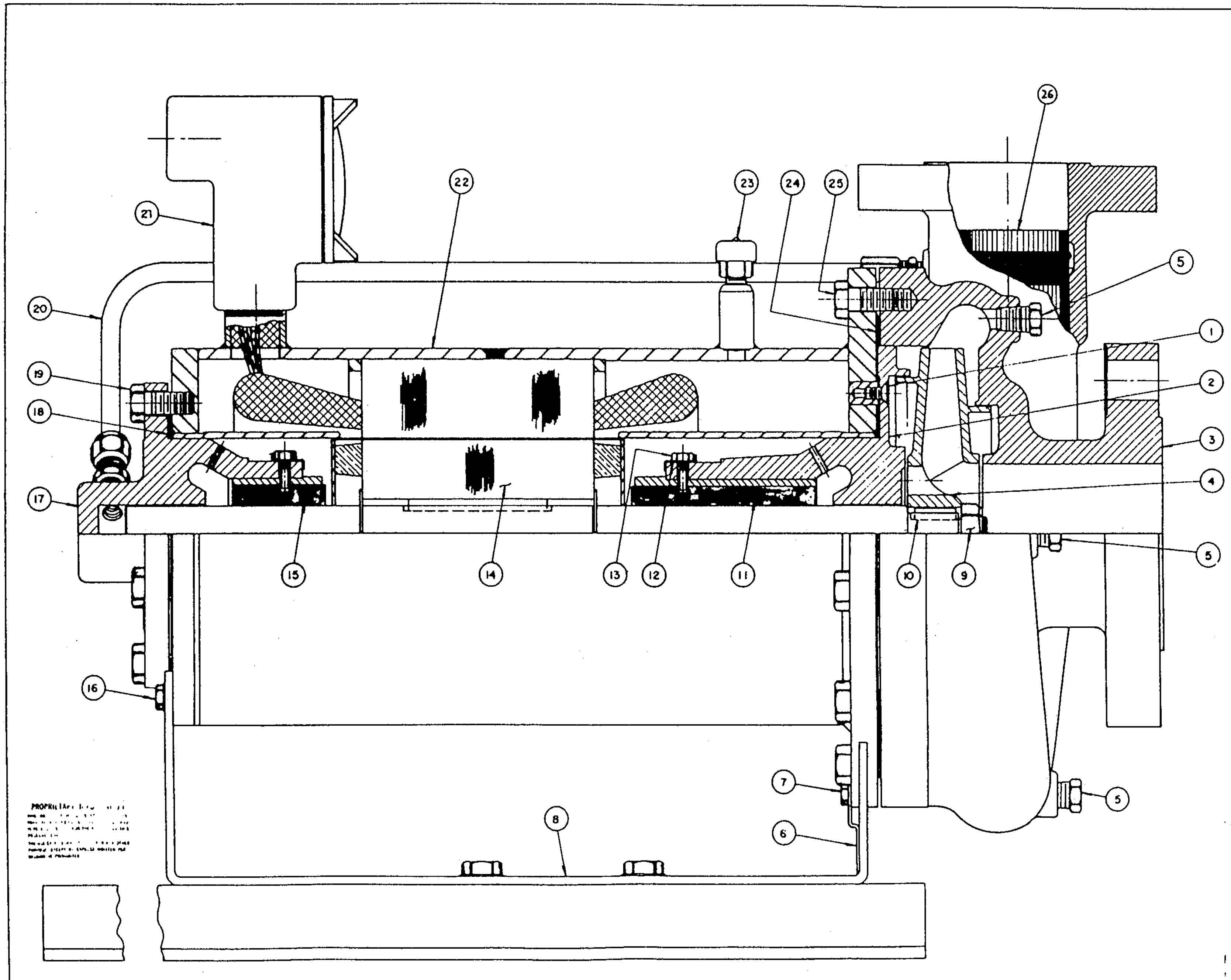
ITEM	QTY	DESCRIPTION	DWG NO
1	1	PUMP CASING	[illegible]
2	1	IMPELLER ASSY	[illegible]
3	1	FRONT BEARING HOUSING	[illegible]
4	3	SCREW, 1/4-20NC X 5/8LG FL HD SOC	[illegible]
5	1	GASKET, [illegible]	[illegible]
6	12	SCREW, 3/8-16NC X 1" HEX HD	[illegible]
7	1	RELIEF VALVE	[illegible]
8	1	STATOR ASSY	[illegible]
9	1	CONNECTION BOX ASSY	[illegible]
10	1	CIRCULATION TUBE	[illegible]
11	6	SCREW, 5/16-18NC X 5/8LG HEX HD	[illegible]
12	1	GASKET, (MOTOR)	[illegible]
13	1	REAR BEARING HOUSING	[illegible]
14	1	SCREW, FLANGED WHIZ-LOCK 1/4-20NC [illegible]	[illegible]
15	2	BEARING ASSY	[illegible]
16	2	LOCKING WASHER	[illegible]
17	2	BEARING SCREW, 1/4-20NC	[illegible]
18	1	ROTOR ASSY	[illegible]
19	1	IMPELLER NUT 3/8-16NC LH	[illegible]
20	3	DRAIN PLUG, 1/8 NPT	[illegible]
21	1	BASE ASSY	[illegible]

CRANE

CHEMPUMP DIVISION
CRANE CO.

MODEL-GA,GB,GC
TYPICAL X-SECT

D 65050 S



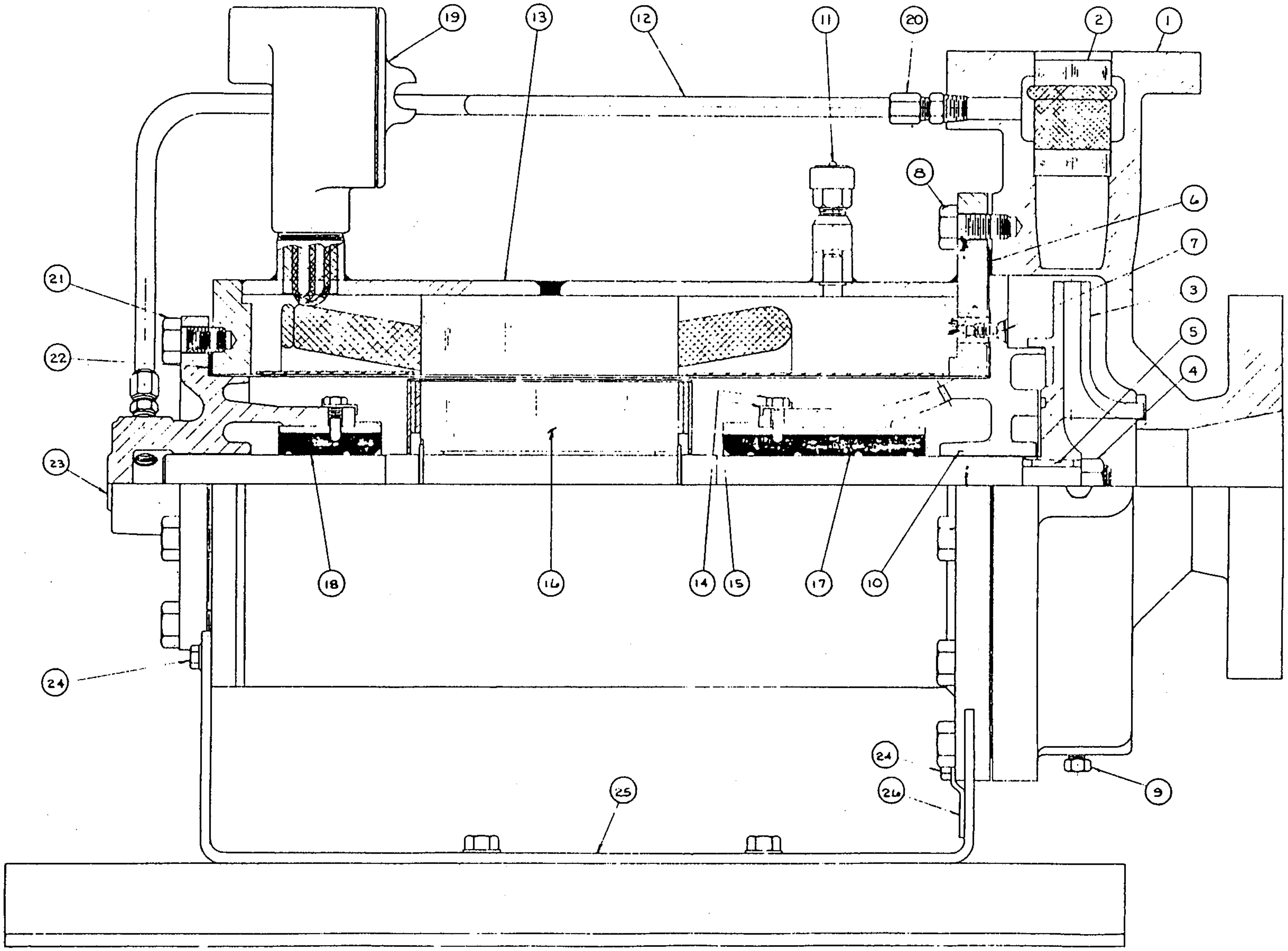
ITEM	QTY	DESCRIPTION	DWG NO
1	3	SCREW, 1/4 - 20 N.C. x 1/2 LG FL. HD. SOC.	A-30080
2	1	FRONT BEARING HOUSING	C-30664
3	1	PUMP CASING	B-30375
4	1	IMPELLER	C-30375
5	3	1/4 N.P.T. PLUG (VENTS & DRAINS)	A-30688
6	1	CLIP, (BASE)	A-30366
7	1	SCREW, 1/4-20 N.C. x 3/4 LG. WHIZ-LOCK	A-30088
8	1	BASE ASSY.	C-30589
9	1	NUT, (IMPELLER) 3/4 - 10 R.H.	A-30630
10	1	KEY, (IMPELLER)	A-30371
11	1	FRONT BEARING ASSY.	B-30800
12	2	LOCKING WASHER	A-30607
13	2	SCREW, BEARING 1/4 - 20 N.C.	A-30888
14	1	ROTOR ASSY	C-30806
15	1	REAR BEARING ASSY	B-30807
16	2	SCREW, 1/4 - 20 N.C. x 3/8 LG WHIZ-LOCK	A-30008
17	1	REAR BEARING HOUSING	C-30883
18	1	GASKET, (MOTOR) ENV	A-30603
19	6	SCREW, 1/2 - 13 N.C. X 7/8 LG. HEX HD.	A-30888
20	1	CIRCULATION TUBE	C-30875
21	1	CONNECTION BOX ASSY	B-30021
22	1	STATOR ASSY.	B-30310
23	1	RELIEF VALVE	A-30060
24	1	GASKET, (PUMP CASING) ENV	A-30662
25	12	SCREW, 1/2 - 13 N.C. X 1" LG. HEX HD.	A-36288
26	1	FILTER ASSY	B-39672

CRANE CHEMPUMP DIVISION

MODEL GD, GE
CROSS SECTION

D 65039 1

32



PARTS LIST

ITEM	QTY	DESCRIPTION	DWG. NO
1	1	PUMP CASING	D 38198
2	1	FILTER ASSY	B 39632
3	1	IMPELLER	C 38196
4	1	IMPELLER NUT 5/8-10 (R.H.)	A 39659
5	1	IMPELLER KEY	A 39371
6	1	GASKET (PUMP CASING) ENV	A 39682
7	3	SCREW, 1/4-20NC × 3/4 LG FL HD SOC.	A 39089
8	12	SCREW, 1/2-13NC × 1" LG HEX HD	A 39252
9	3	HEX PLUG 1/4 NPT (VENT & DRAINS)	A 39665
10	1	FRONT BEARING HOUSING	C 38167
11	1	RELIEF VALVE	A 39960
12	1	CIRCULATION TUBING	
13	1	STATOR ASSY	D 38553
14	2	BEARING HOUSING SCREW	A 38868
15	2	LOCKING WASHER	A 38867
16	1	ROTOR ASSY	C 38264
17	1	FRONT BEARING ASSY	B 38859
18	1	REAR BEARING ASSY	B 38857
19	1	CONNECTION BOX ASS'Y	B 39921
20	2	TUBE FITTING, STR. 1/4 NPT × 3/8 TUBE	A 39629
21	6	SCREW, 1/2-13NC × 7/8" LG HEX HD	A 39252
22	1	GASKET (MOTOR) ENV.	A 39682
23	1	REAR BEARING HOUSING	C 38504
24	3	SCREW, 1/4-20NC × 3/8 LG WHIZLOCK	A 39058
25	1	BASE ASSY	C 39369
26	1	BASE CLIP	A 39366

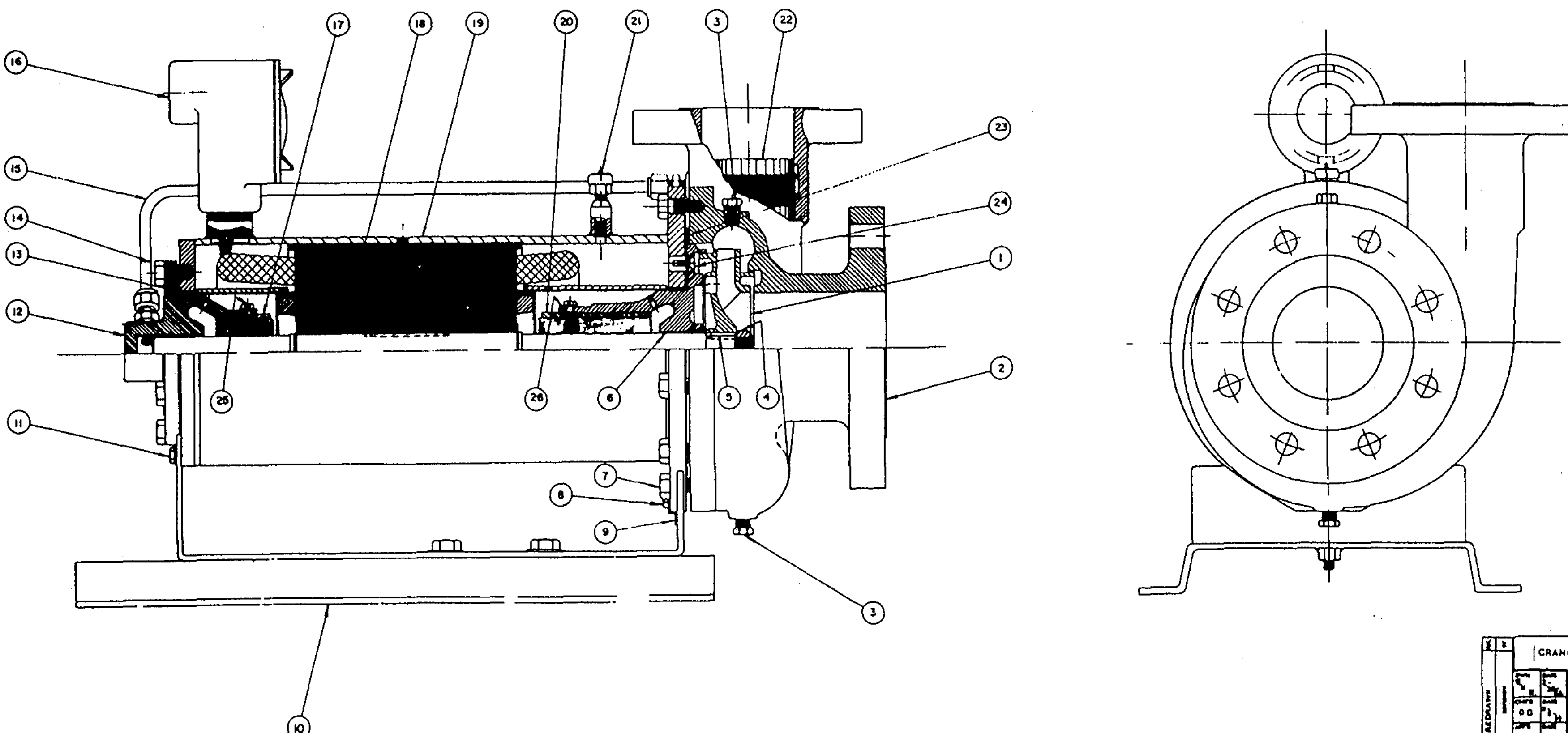
CRANE
CHEMPUMP DIVISION
CRANE CO

CROSS SECTION
MODEL - GVD
TYPICAL

D 65107

PARTS LIST			
ITEM	QTY	DESCRIPTION	DWG NO
1	1	IMPELLER	C - 38964
2	1	PUMP CASING	D - 38966
3	2	1/4 NPT PLUG (VENT & DRAIN)	A - 39655
4	1	NUT (IMPELLER) 3/4-10R H	A - 39659
5	1	KEY (IMPELLER)	A - 39371
6	1	FRONT BEARING HOUSING	C - 38879
7	12	SCREW 1/2-13N.C×1" LG HEX-HD	A - 39252
8	1	SCREW 1/4-20N.C (WHIZ-LOCK)×3/8LG	A - 39058
9	1	CLIP (BASE)	A - 39366
10	1	BASE ASSY	C - 39369
11	2	SCREW 1/4-20NC (WHIZ-LOCK)×3/8LG	A - 39058
12	1	REAR BEARING HOUSING	C - 38863
13	1	GASKET (MOTOR) (ENV)	A - 38682

PARTS LIST			
ITEM	QTY	DESCRIPTION	DWG NO.
14	6	SCREW 1/2-13NC×7/8LG HEX-HD.	A - 39252
15	1	CIRCULATION LINE	C - 39372
16	1	CONNECTION BOX ASSY.	B - 39921
17	1	REAR BEARING ASSY.	B - 38857
18	1	ROTOR ASSY	C - 38884
19	1	STATOR ASSY	D - 39310
20	1	FRONT BEARING ASSY	B - 38858
21	1	RELIEF VALVE	A - 39060
22	1	FILTER ASSY	B - 39632
23	1	GASKET (PUMP CASING) (ENV)	A - 39681
24	3	SCREW 1/4-20N.C×1/2LG. FL. HD. SOC	A - 39081
25	2	BEARING HOUSING SCREW 1/4-20N.C	A - 3880
26	2	LOCKING WASHER	A - 3888



CRANE

CHEMPUMP DIVISION

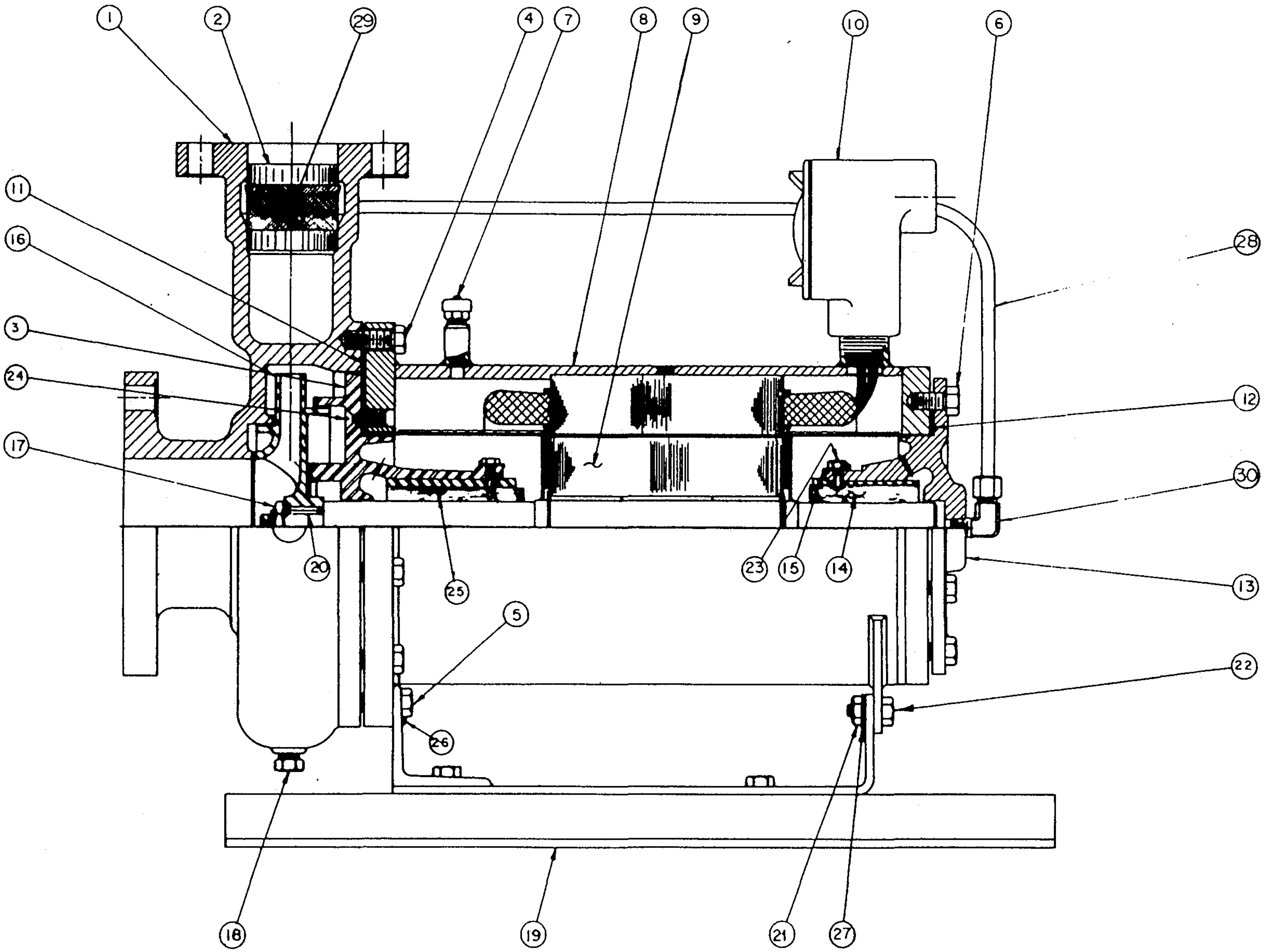
CROSS SECTION

MODEL GG

REDRAWN

D

68041



PARTS LIST

ITEM	QTY	DESCRIPTION	DWG. NO.
1	1	PUMP CASING	[illegible]
2	1	FILTER ASS'Y	[illegible]
3	1	FRONT BEARING HOUSING	[illegible]
4	10	SCREWS, 1/2-13 N.C. X 1 1/2 LG. HEX HD.	[illegible]
5	2	SCREWS, 1/2-13 N.C. X 1 1/4 LG. HEX HD.	[illegible]
6	6	SCREWS, 1/2-13 N.C. X 1" LG. HEX HD.	[illegible]
7	1	RELIEF VALVE	[illegible]
8	1	STATOR ASS'Y	[illegible]
9	1	ROTOR ASS'Y	[illegible]
10	1	CONNECTION BOX ASS'Y	[illegible]
11	1	GASKET, P.C. ENVELOPE	[illegible]
12	1	GASKET, MOTOR ENVELOPE	[illegible]
13	1	REAR BRG. HSG.	[illegible]
14	1	REAR BRG. ASS'Y	[illegible]
15	2	LOCKING WASHER	[illegible]
16	1	IMPELLER	[illegible]
17	1	IMPELLER NUT, 3/4-10 N.C. R.H.	[illegible]
18	1	PLUG, 1/4 N.P.T.	[illegible]
19	1	BASE ASS'Y	[illegible]
20	1	IMPELLER KEY	[illegible]
21	2	NUT, 1/2-13 N.C.	[illegible]
22	1	SCREW, 1/2-13 N.C. X 1 1/4" LG.	[illegible]
23	2	BEARING SCREW, 1/4-20 N.C.	[illegible]
24	3	RETAINING SCREWS, F.B.H. 1/4-20 N.C. FL. HD. SOC.	[illegible]
25	1	FRONT BEARING ASS'Y.	[illegible]
26	1	1/4-20 N.C. X 1/2 LG. [illegible] LOCK SCREW	[illegible]
27	2	LOCK WASHER, 1/2"	[illegible]
28	1	CIRCULATION TUBE	[illegible]
29	1	FITTING, STR. TUBE 1/4 N.P.T. X 3/8 TUBE	[illegible]
30	1	FITTING, ELB. TUBE 1/4 N.P.T. X 3/8 TUBE	[illegible]

CRANE

CHEMPUMP DIVISION
CRANE CO.

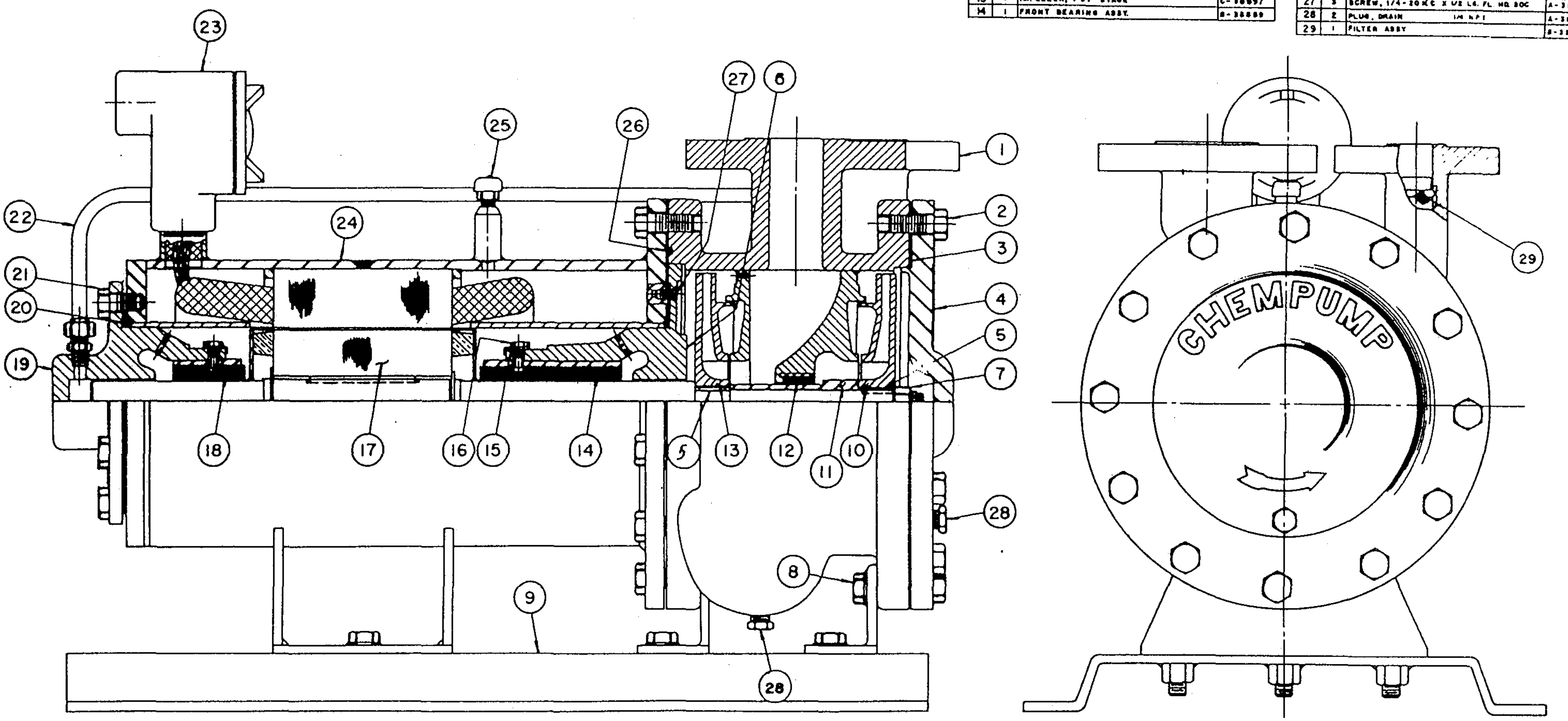
MODEL GVM

CROSS SECTION (TYPICAL)

D 65095

SCALE HALF

ITEM	QTY.	DESCRIPTION	DWG NO
1	1	PUMP CASING ASSY.	D-38833
2	24	SCREW, 1/2-13 N.C. X 1 LG. HEX HD.	A-39252
3	1	GASKET,(FRONT COVER) ENV.	A-39862
4	1	COVER PLATE, PUMP CASING	C-39366
5	2	KEY, IMPELLER	A-39371
6	1	FRONT BEARING HOUSING	C-38861
7	1	NUT, IMPELLER 5/8-11 N.C. R.H. FLEXLOC	A-39869
8	3	SCREW, 1/2-13 N.C X 1 LG. WHIZ-LOCK	A-39058
9	1	BASE ASSY.	D-39004
10	1	IMPELLER, 2 ND STAGE	C-38897
11	1	IMPELLER SPACER	A-39389
12	1	IDLER BEARING ASSY.	A-39360
13	1	IMPELLER, 1 ST STAGE	C-38897
14	1	FRONT BEARING ASSY.	B-38889
15	2	LOCKING WASHER	A-38887
16	2	BEARING SCREW, 1/4-20 N.C	A-38886
17	1	ROTOR ASSY	C-39364
18	1	REAR BEARING ASSY	B-38887
19	1	REAR BEARING HOUSING	C-38863
20	1	GASKET, (MOTOR) ENV	A-39862
21	6	SCREW, 1/2-13 N.C X 7/8 LG. HEX. HD	A-39232
22	1	CIRCULATION TUBE	C-39303
23	1	CONNECTION BOX ASSY	B-30921
24	1	STATOR ASSY	D-39310
25	1	RELIEF VALVE	A-39960
26	1	GASKET "O" RING	A-39680
27	3	SCREW, 1/4-20 N.C X 1/2 LG. FL. HD. SOC	A-39069
28	2	PLUG, DRAIN 1/4 NPT	A-39666
29	1	FILTER ASSY	B-39632



CRANE CHEMPUMP DIVISION

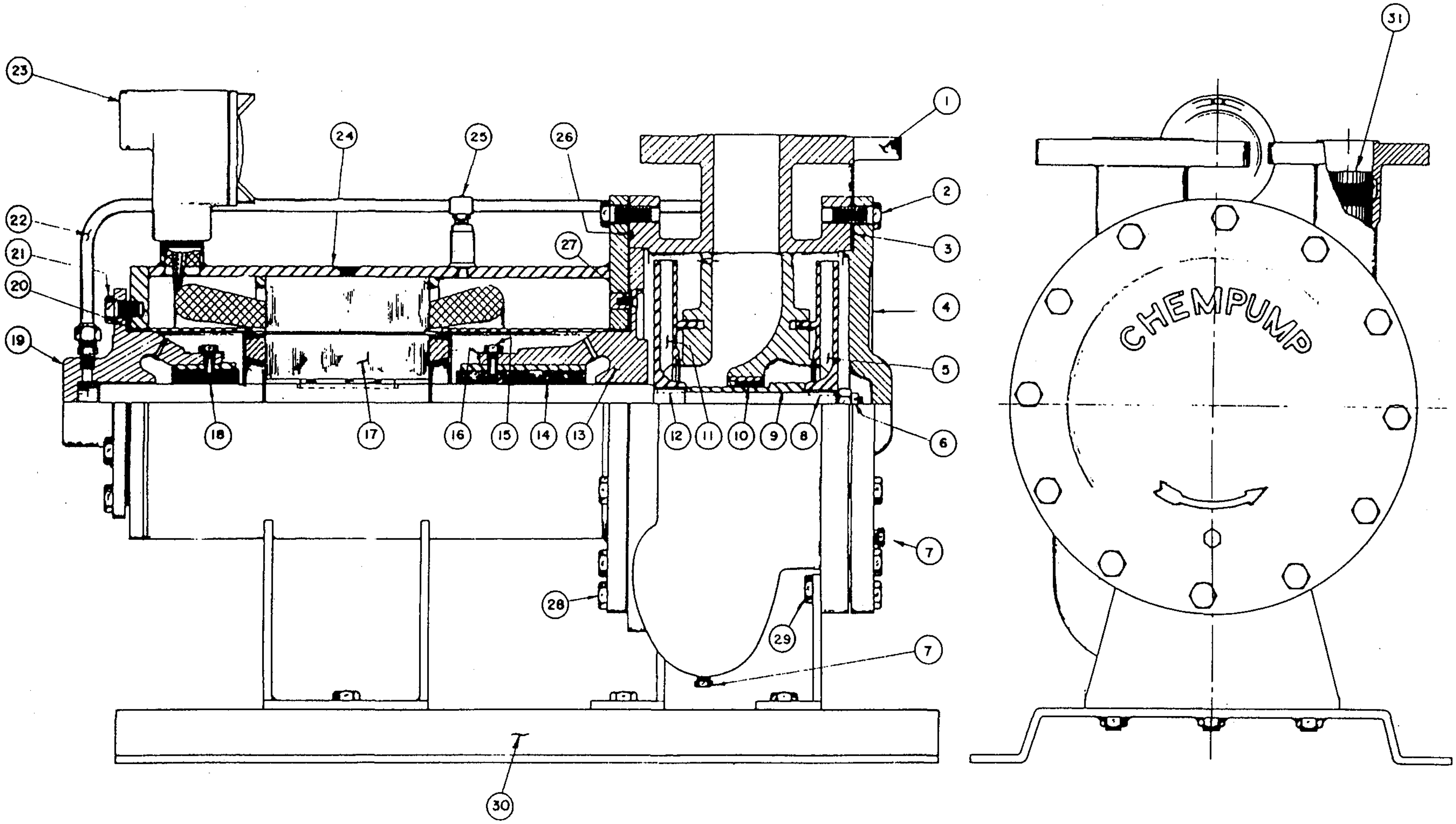
MODEL 3GFD CROSS SECTION

SCALE HALF

D 65057

ITEM	QTY	DESCRIPTION	DWG NO
1	1	PUMP CASING ASSY	D 39249
2	12	SCREW, 1/2-13 NC X 1" LG HEX HD	A 39252
3	1	GASKET, (FRONT COVER) ENV	A 39482
4	1	FRONT COVER PLATE	C 39247
5	1	IMPELLER ASSY 2ND STAGE	C 39246
6	1	NUT, IMPELLER 3/8 [illegible]	A 39459
7	2	DRAIN PLUG 1/4 N P T	A 39455
8	1	KEY, IMPELLER	A 39371
9	1	SPACER, IMPELLER	A 39359
10	1	IDLER BEARING ASSY	A 39358
11	1	IMPELLER ASSY 1ST STAGE	C 39248
12	1	KEY, IMPELLER	A 39371
13	1	FRONT BEARING HOUSING	C 38881
14	1	FRONT BEARING ASSY	B 38859
15	2	SCREW, BEARING 1/4-20 NC	A 38888

ITEM	QTY	DESCRIPTION	DWG NO
16	2	LOCKWASHER	A 38887
17	1	ROTOR ASSY	C 39364
18	1	REAR BEARING ASSY	B 38887
19	1	REAR BEARING HOUSING	C 38883
20	1	GASKET, (MOTOR) ENV	A 39682
21	4	SCREW, R H M 1/2-13 NC X [illegible] HD	A 39262
22	1	CIRCULATION LINE	C 39303
23	1	CONNECTION BOX ASSY	B 39921
24	1	STATOR ASSY	D 39309
25	1	RELIEF VALVE	A 39940
26	1	GASKET, "O" RING	A 39660
27	3	SCREW, F H M 1/4-20 NC X 1/2 FL HD SOC	A 39059
28	12	SCREW, 1/2-13 NC X 1 LG HEX HD	A 39252
29	3	SCREW, BASE 1/2-13 NC X 1" WHIZ-LOCK	A 39058
30	1	BASE ASSY	D 39004
31	1	FILTER ASSY	B 39623

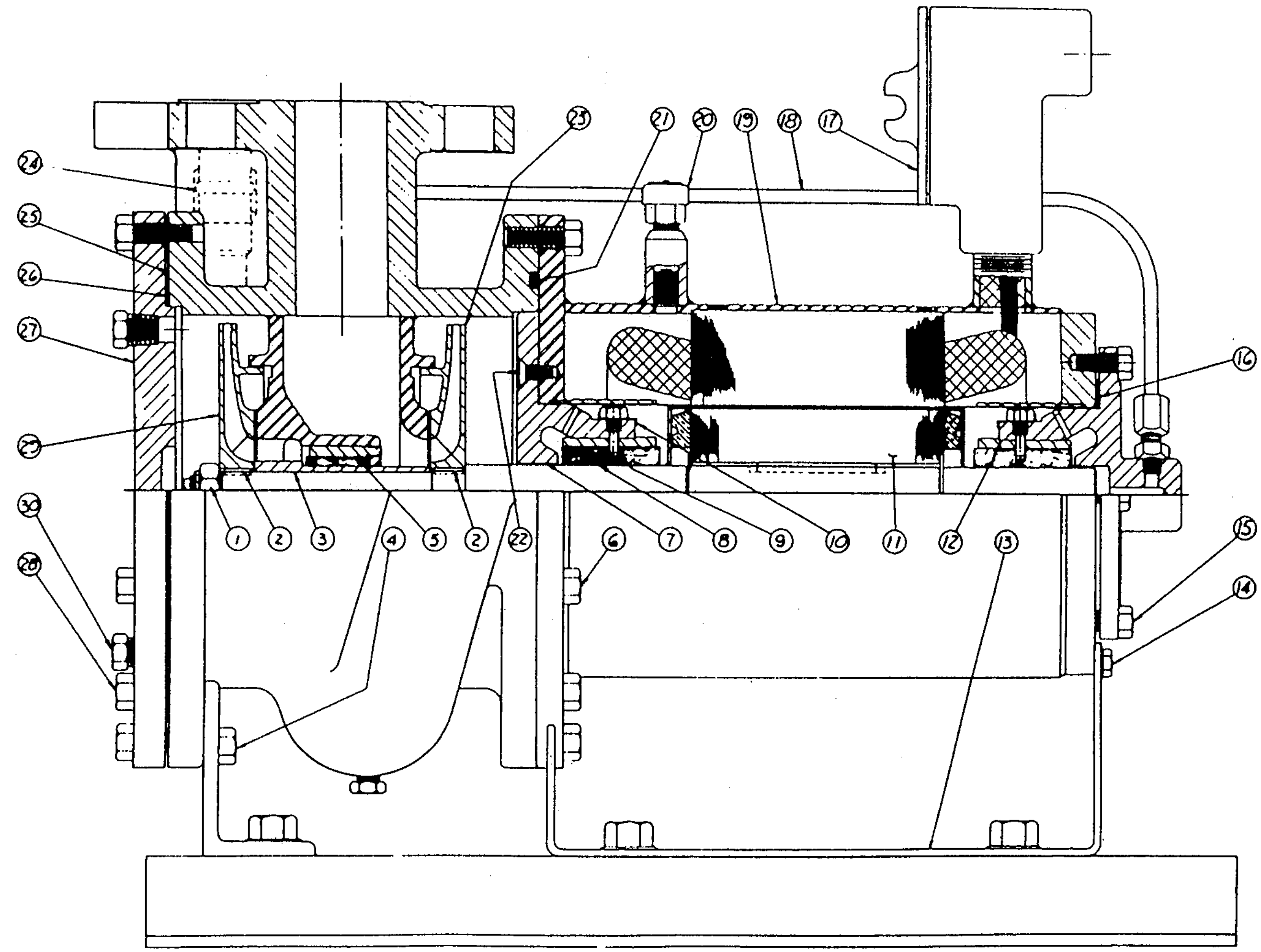


CRANE CHEMPUMP DIVISION

MODEL "GHD"
CROSS SECTION

SCALE HALF

D 65043 1



PARTS LIST			
ITEM	QT'Y	DESCRIPTION	DWG NO
1	1	IMPELLER NUT	A 35659
2	2	IMPELLER KEY	A 35371
3	1	IMPELLER SPACER	A 38702
4	2	SCREW 3/8-16 NC × 3/4 LG HEX HD	A-35253
5	1	IDLER BEARING ASS'Y	A-35358
6	12	SCREW 3/8-16 NC × 1" LG HEX HD	A-35253
7	1	FRONT BEARING HOUSING	C-38792
8	2	BEARING ASS'Y	A-38816
9	2	BEARING HOUSING SCREW 1/4-20 NC	A-38888
10	2	LOCKING WASHER	A-38887
11	1	ROTOR ASS'Y	C-38784
12	1	REAR BEARING HOUSING	C-38863
13	1	BASE ASS'Y	C 38781
14	1	SCREW 1/4-20 NC × 1/2 LG (WHIZLOCK)	A-35038
15	6	SCREW 5/16-18 NC × 3/4 LG HEX HD	A 35254
16	1	GASKET (ENV.) 3 ID × 4 OD	A-35682
17	1	CONNECTION BOX ASS'Y	B 35521
18	1	CIRCULATION LINE ASS'Y	C-38788
19	1	STATOR ASS'Y	D-35467
20	1	RELIEF VALVE	A-35560
21	1	GASKET 7" ID × 7 1/2 OD (O RING)	A 35660
22	3	SCREW 1/4 20 NC × 3/4 LG FL HD SOC	A-35039
23	1	IMPELLER 1st STAGE	C 38783
24	1	FILTER ASS'Y	B-35632
25	1	PUMP CASING ASS'Y	D 38751
26	1	GASKET 6 1/4 ID × 7 1/4 OD (ENV.)	A 35682
27	1	COVER PLATE	C-38750
28	12	SCREW 3/8-16 NC × 1" LG HEX HD	A-35253
29	1	IMPELLER 2nd STAGE	C-38183
30	3	VENT & DRAIN PLUG 1/4 NPT	A-35655

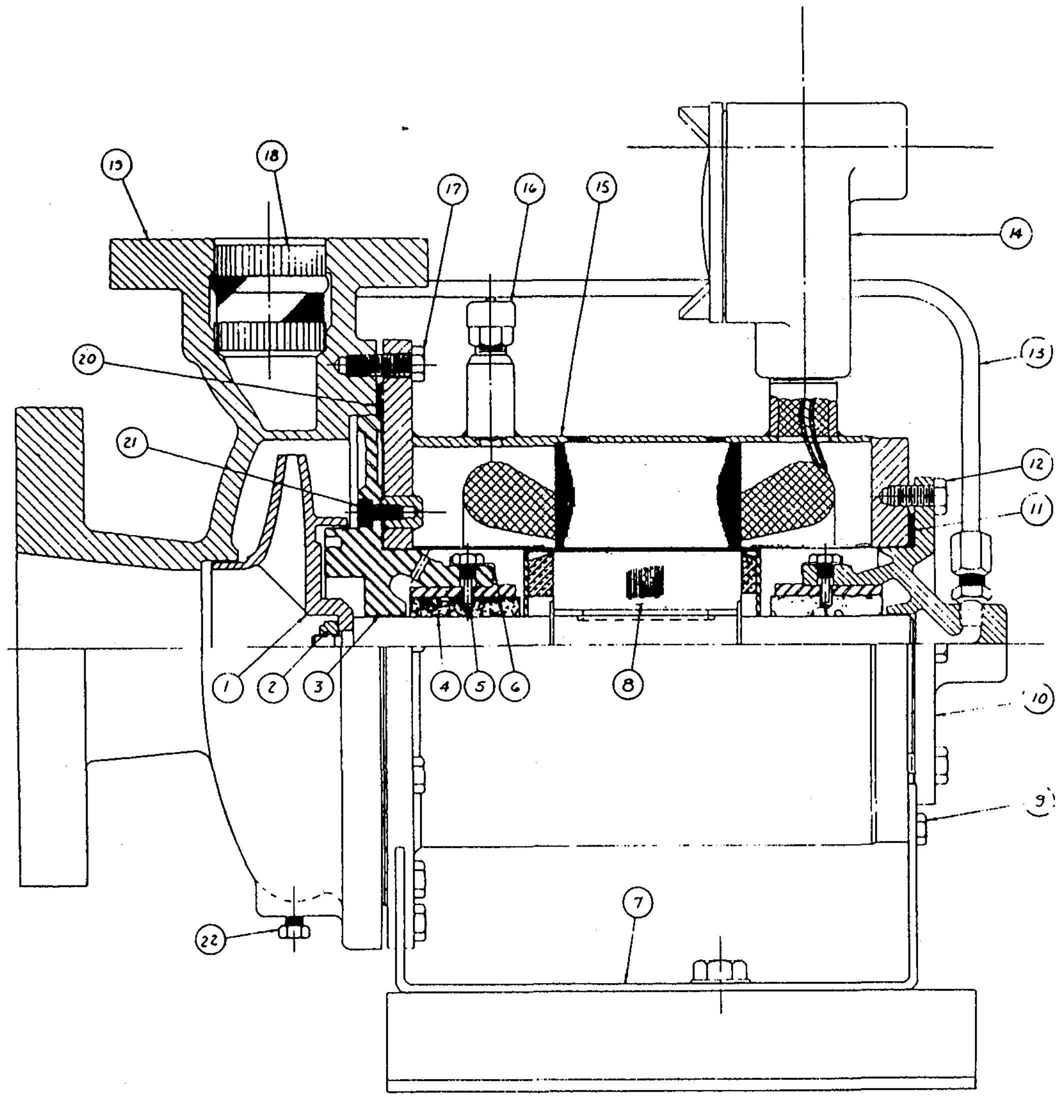
CRANE

CHEMPUMP DIVISION

JFK

MODEL GLD
CROSS-SECTION

A 65060



PARTS LIST

ITEM	QTY	DESCRIPTION	DWG NO
1	1	IMPELLER ASS'Y	C-38777
2	1	IMPELLER NUT 1/2-16 NC L.H	A-37653
3	1	FRONT BEARING HOUSING	C-38776
4	2	BEARING ASS'Y	A-38876
5	2	BEARING SCREW 1/4-20 NC	A-[illegible]
6	2	LOCKING WASHER	A-38887
7	1	BASE ASS'Y	C-39463
8	1	ROTOR ASS'Y	C-39491
9	1	SCREW FLANGED WHIZ LOCK 1/4-20 NC x 3/8	A-39058
10	1	REAR BEARING HOUSING	C-38583
11	1	GASKET (MOTOR)	A-39682
12	6	SCREWS 5/16-18NC x 3/4 LG HEX H'D	A-39256
13	1	CIRCULATION TUBE	C-38772
14	1	CONNECTION BOX ASS'Y	B-39921
15	1	STATOR ASS'Y	D-38563
16	1	RELIEF VALVE	A-39560
17	12	SCREWS 3/8-16 NC x 1" LG HEX H'D	A-39253
18	1	FILTER ASS'Y	B-39658
19	1	PUMP CASING	D-38775
20	1	GASKET (P.C)	A-39683
21	3	SCREW 1/4-20NC-5/8 LG SOC H'D	A-38976
22	1	PLUG DRAIN 1/8-27NPT	A-39655

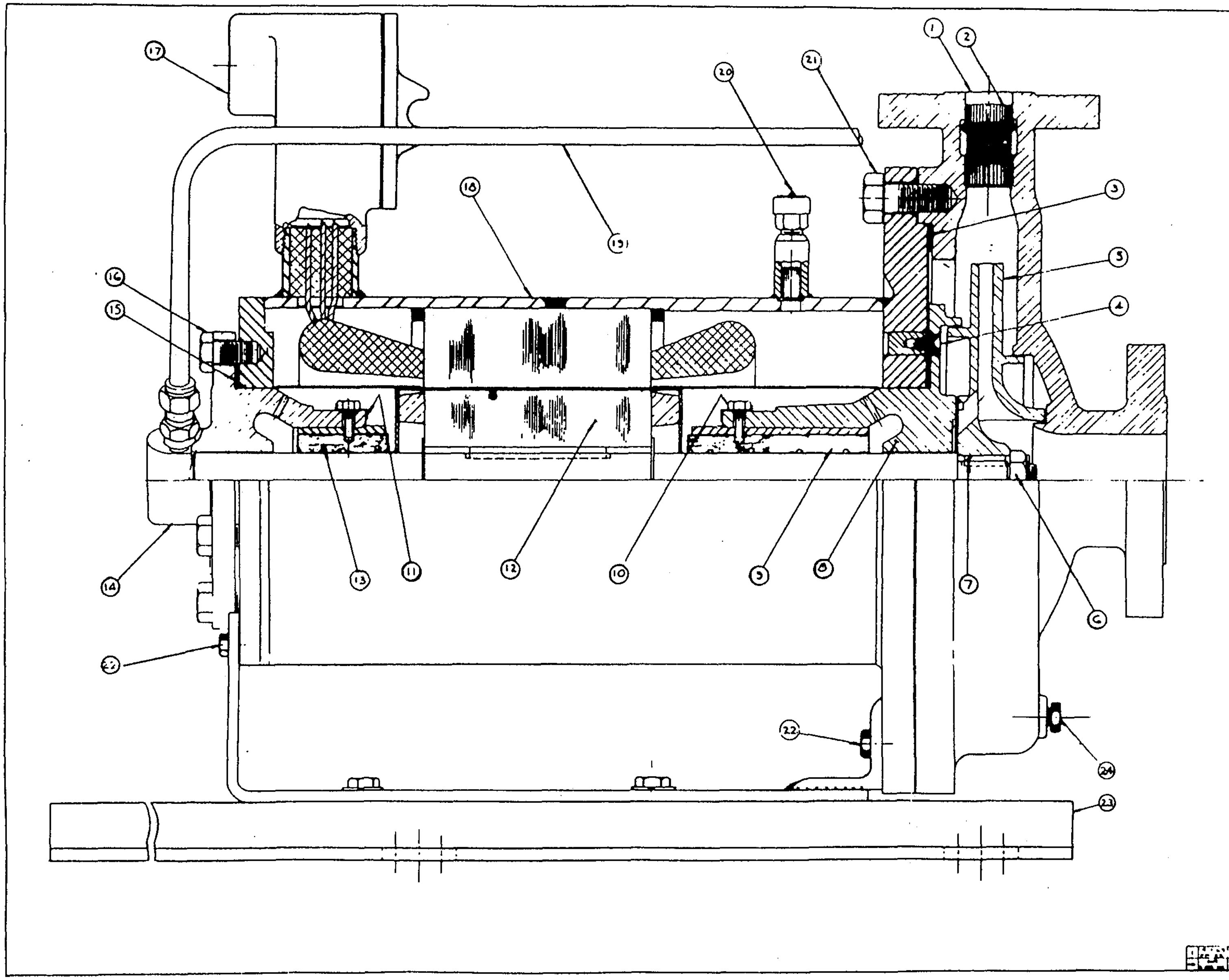
CRANE

CHEMPUMP DIVISION
CRANE CO.

CROSS SECTION
MOD. GVBS
(TYPICAL)

FULL D 65061 3

3 | 3/1/72 | REDRAWN



PARTS LIST

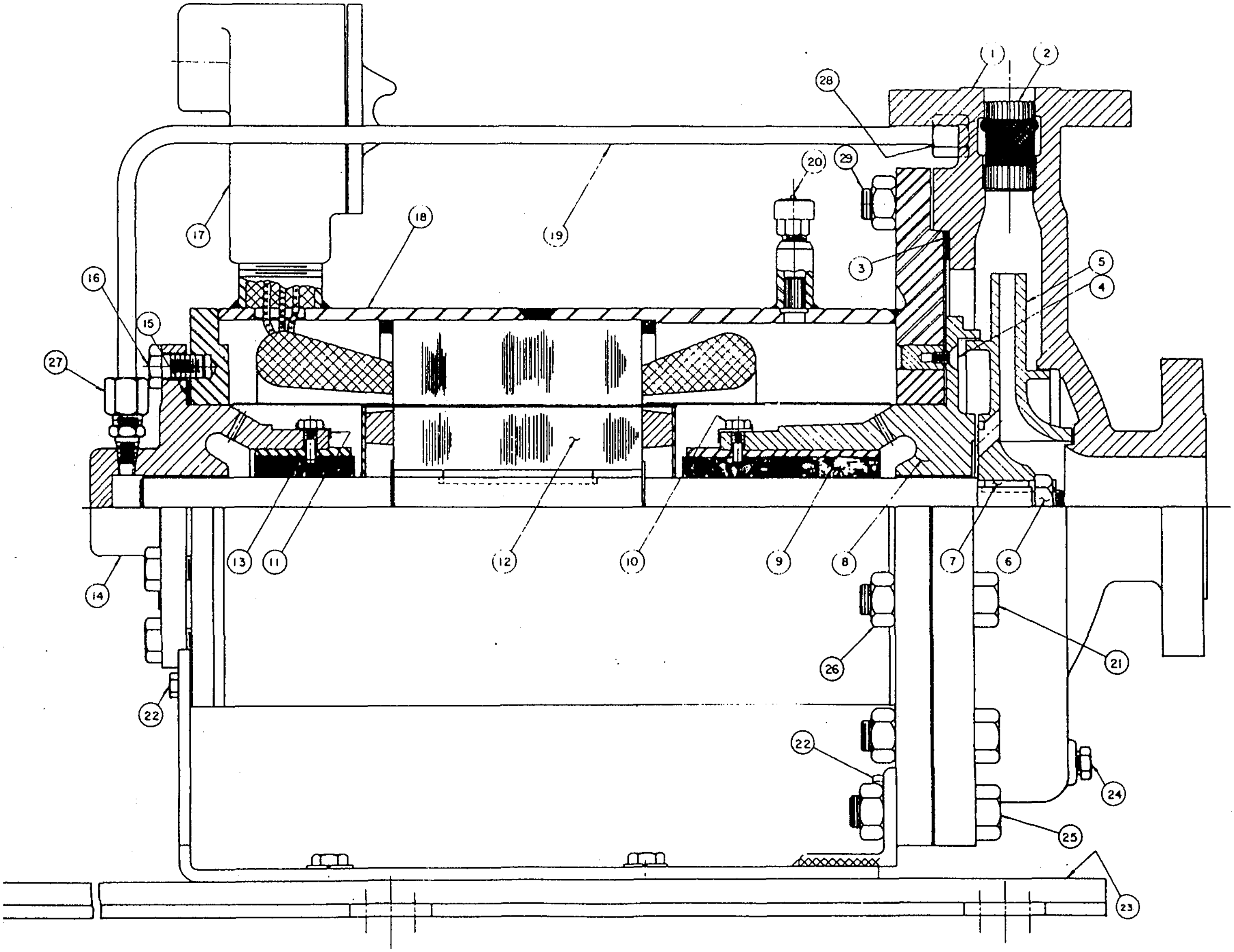
ITEM	QTY	DESCRIPTION	DWG NO
1	1	PUMP CASING	D-34808
2	1	FILTER ASSEMBLY	B-39631
3	1	GASKET (PUMP CASING) TNV 10.10 x 11.00	A-33682
4	3	SCREW 1/4-20 NC x [illegible] FL HD SOC	A-33013
5	1	IMPELLER	C-38508
6	1	IMPELLER NUT 3/8-16 (R.H.)	A-39633
7	1	IMPELLER KEY	A-33371
8	1	FRONT BEARING HOUSING	C-34884
9	1	FRONT BEARING ASSEMBLY	B-34037
10	3	BEARING HOUSING SCREW 1/4-20 NC	A-[illegible]
11	2	LOCKING WASHER	A-38487
12	1	ROTOR ASSEMBLY	C-33384
13	1	REAR BEARING ASSEMBLY	B-34827
14	1	REAR BEARING HOUSING	C-34886
15	1	GASKET (MOTOR) TNV	A-33681
16	6	SCREW 3/8-16 NC x 3/4 LG HEX HD	A-32232
17	1	CONNECTION BOX ASSEMBLY	B-38831
18	1	STATOR ASSEMBLY	D-[illegible]
19	1	CIRCULATION TUBING	C-38187
20	1	RELIEF VALVE	A-37998
21	12	SCREWS 5/8-11 NC x [illegible] LG HEX HD	A-32331
22	3	SCREWS 1/4-20 NC x 1/2 LG WHITLOCK	A-33088
23	1	BASE ASSEMBLY	C-39321
24	3	PIPE PLUG 1/4 NPT (VENTS & DRAINS)	A-33658

CRANE

CHEMPUMP DIVISION
CRANE CO.

MODELS
GVE-GVH
TYPICAL X-SECT.

D 65088 1



PARTS LIST

ITEM	QTY	DESCRIPTION	DWG NO
1	1	PUMP CASING	D-38892
2	1	FILTER ASS'Y	B-39632
3	1	GASKET(PUMP CASING)ENV 10 I D X 11 1/8 O.D.	A-39482
4	3	SCREW 1/4-20 NC X 1/2 LG FL HD SOC	A-39059
5	1	IMPELLER	C-38508
6	1	IMPELLER NUT 3/4-10	A-39459
7	1	IMPELLER KEY	A-39371
8	1	FRONT BEARING HOUSING	C-38416
9	1	FRONT BEARING ASS'Y	[illegible]
10	2	BEARING HOUSING SCREW	A-38886
11	2	LOCKING WASHER	A-38887
12	1	ROTOR ASS'Y	C-39384
13	1	REAR BEARING ASS'Y	B-38457
14	1	REAR BEARING HOUSING	C 38504
15	1	GASKET(MOTOR)ENV 4 1/8 I D X 5 O D	A-39482
16	6	SCREW 1/2-13 N C X 7/8 LG HEX HD	A-39252
17	1	CONNECTION BOX ASS'Y	B-39921
18	1	STATOR ASS'Y	D-38514
19	1	CIRCULATION TUBING	C-38507
20	1	RELIEF VALVE	A-38960
21	9	SCREWS 5/8-11 N C X 2-1/2 LG HEX HD	A-39251
22	3	SCREWS 1/4-20 N C X 1/2 LG WHIZLOCK	A-39058
23	1	BASE ASS'Y	C-38388
24	1	DRAIN PLUG, 1/4 N PT	A-39486
25	2	SCREWS, 5/8-11 N.C X 2-3/4 LG HEX HD	A-39281
26	12	NUT, 5/8-11 N C HEX	A-39040
27	1	FITTING, 1/4 N P T X 3/8 TUBE STRAIGHT	A-39629
28	1	FITTING, 1/4 N PT X 3/8 TUBE ELBOW	A-39628
29	1	SCREW, 5/8-11 N C X 4-1/2 LG HEX HD	[illegible]

CRANE

CHEMPUMP DIVISION
CRANE CO

CROSS-SECTION
MODEL GVHS

DRN	DATE	CHKD	DATE	APPVD	DATE
KL	12 20 76	EM	3 7 77	WAM	4 7 77

NO.	DATE	REVISION	BY
2	[illegible]	REDRAWN	

SCALE

D DWG NO 65104 REV 2

ADAPTOMODE© INLET PRESSURE REGULATORS

Type, A4AS, A4AB, A4AD, A4AZ

Port Size 20 - 100 mm (3/4"-4")
For Ammonia, R-12, R-22, R-502
Other Refrigerants and Oil

FEATURES

- Pilot operated characterized Modulating Plug for precise control
- Suitable for all common refrigerants and oil
- 21 bar (300 psig) maximum rated pressure (MRP)
- Flanges for threaded or welded steel pipe and copper tube (copper not for ammonia)
- Unique Modular construction
- Interchangeable parts
- Easy to service
- Close coupled strainers, optional
- Many control variations are possible with the use of a few Modules and kits.
- Stainless Steel Diaphragm
- Chrome Plated Pilot Seat
- Manual Opening Stem

A4AZ

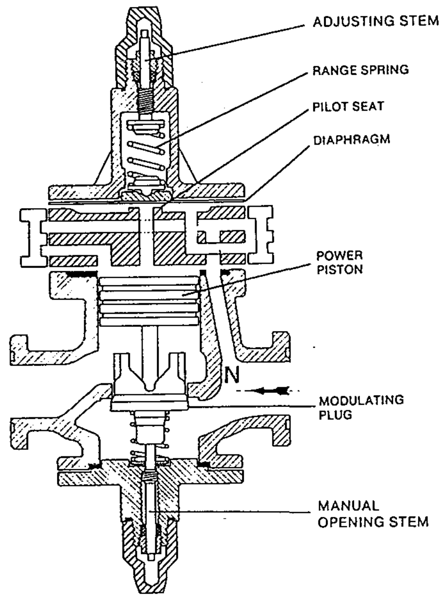


Fig. 1

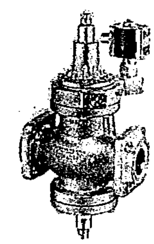
Description:

These compact, heavy duty, pilot operated, iron alloy (ASTM A126 Class B high strength semi-steel) Inlet Pressure Regulators are suitable for Ammonia, R-12, R-22, R-502 and other common refrigerants and fluids approved for use in refrigeration systems.

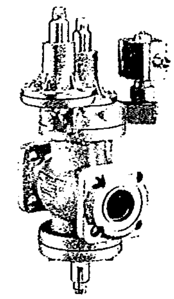
All A4 Regulators are pilot operated using upstream pressure for the opening force and requires a minimum 0.14 bar (2 psi) pressure drop to fully open.

These valves are generally ordered with close coupled upstream strainer to prevent entrance of foreign material into the valve and the rest of the system. (See current Bul 00-10 for strainer information.)

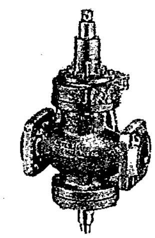
BULLETIN 23-06
A4A SERIES



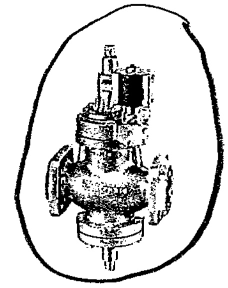
A4AS



A4AD



A4AZ



A4AB

May 1987
Installation, Service and Parts Information

Purpose

Modulates flow of refrigerant gas or liquid to maintain a constant upstream (or inlet) pressure as set-for, despite load fluctuations.

The fluid temperature range for the A4 Series of Regulators is —45°C to 105°C (—50°F to 220°F).

Principles of Operation (See Fig. 1)

The inlet pressure enters the space under the diaphragm through passage N. When the force created by the pressure exceeds the force of the range spring, the diaphragm is lifted off the pilot seat allowing pressure to enter on top of the power piston. This causes the power piston to move downward forcing the modulating plug to open and modulate to maintain constant inlet pressure. An increase in inlet pressure lifts the diaphragm further, allowing more pressure on top of the power piston and opening the valve wider. A decrease in inlet pressure causes the diaphragm to move closer to the pilot seat reducing the pressure on the top of the power piston and causing the closing spring to reduce the valve opening. The pressure on top of the power piston is controlled by the flow through the pilot seat and the bleed off through the bleed hole in the power piston and through the clearance between the piston and cylinder. A minimum of 0.14 bar (2 psi) pressure drop across the valve is required to open it fully.

The A4A Inlet Pressure Regulator therefore opens on a rise in the inlet pressure above its set point and closes on a drop in inlet pressure below its set point. The inlet pressure set point is not appreciably affected by variations in the outlet pressure.

Manual Opening Stem

All Type A4A Regulators are provided with a manual opening stem. To open the regulator manually, back the stem out (turn counter-clockwise) until it stops. To put the regulator into automatic operation, turn the stem in (clockwise) until only the flats on the stem protrude from the packing nut.

Adjustment

Install an accurate pressure gauge in the gauge port. Back the adjusting stem all the way out to stop. This will reduce the set point to its lowest level and cause the valve to open wide. Start the system, and when suction pressure is about the desired pressure, turn the adjusting stem in until the pressure gauge shows a slight rise in the inlet pressure. At this point the adjusting stem may be turned in (clockwise) to raise the pressure further, or backed out (counter-clockwise) to lower it; but the final adjustment should be made after the system has been operating for a period of time.

INLET PRESSURE SETTING RANGES

Set Point Ranges	Approx. Pressure Change per Turn of Adjusting Screw	Factory Set Point (unless otherwise) specified)
A:0 to 10.3 bar (0 to 150 psig)	1.7 bar (25 psi)	2.8 bar (40 psig)
V:500mm hg to 8.3 bar (20in hg to 120 psig)	1.7 bar (25 psi)	1.0 bar (15 psig)
D:5.2 to 19.3 bar (75 to 280 psig)	3.7 bar (53 psi)	9.7 bar (140 psig)

Type A4AZ (See Figs 1 and 2)

Description

The A4AZ Inlet Pressure Regulator is the basic building block from which most Series A4 variations are made. This regulator incorporates the specially designed Modudapter© to accommodate the Adaptomode© bolt on modules, providing unique modular construction and many control valve variations with the use of a few modules and kits. See page 3 for an explanation of "Basic Adaptomode Functions", describing modules, module placement and schematic pilot circuit flow diagrams for all variations covered within this bulletin.

The A4AZ regulator is a complete factory assembled and bench tested valve and, in itself, may be used as a basic inlet pressure regulator. In addition, this valve can easily be modified in the field to perform the function of the A4AS, A4AB or A4AD valve variations.

Type A4AS (See Fig. 3)

Description

The Type A4AS is an inlet pressure regulator with a pilot electric shut off. The integrally mounted solenoid must be energized for the valve to function as a regulator. When de-energized the regulator is closed regardless of inlet pressure.

Purpose

The Type A4AS should be used whenever it is required to stop all flow (in the normal fluid flow direction) through the regulator. This could include use in defrost applications as well as part of a temperature control system.

Principles of Operation

The operation of the A4AS is the same as that described on page 1, except the inlet pressure from passage N must pass through the S6A Pilot Solenoid Valve before it can reach the diaphragm. Thus the S6A Pilot Solenoid must be energized before the A4AS can begin to regulate regardless of inlet pressure.

Adjustment

With the solenoid pilot electrically energized, proceed as described above.

Type A4AB (See Fig. 4)

Description

The Type A4AB is an Inlet Pressure Regulator with a Pilot Electric Wide-opening, or Bypass, variation. When the integrally mounted solenoid is energized the main valve is wide open, thereby bypassing the regulator function i.e. not regulating. However, in the wide open mode the regulator will still require the 0.14 bar (2 psi) minimum pressure drop. When the solenoid is de-energized the valve functions as an Inlet Pressure Regulator.

Purpose

The Type A4AB frequently is used with the wide-open functi where maximum refrigeration capacity from an evaporator is required. During the defrost of the evaporator, the regulator pilot solenoid is de-energized thus functioning as a defrost relief regulator or for high pressure limit protection.

When used in a discharge pressure line, it can when de-energized, hold back enough pressure for some heat reclaim or defrosting function and then, when energized, allow the discharge pressure to drop to a lower level. Frequently this regulator is used in the wide open mode for evaporator pump out prior to hot gas defrost.

Principles of Operation

The operation of the A4AB is the same as that described on page 1 when operating as a regulator (Pilot Solenoid de-energized). When the solenoid is energized the upstream pressure from passage N bypasses the underside of the diaphragm and is fed directly to the top of the piston where, provided a 0.14 bar (2 psi) pressure difference exists across the main valve, the Modulating Plug will be held wide open.

Adjustment

With the solenoid pilot electrically de-energized, proceed as described above.

Type A4AD (See Fig. 5)

Description

The Type A4AD is a Dual Inlet Pressure Regulator capable of regulating at two different pressure set-points. When the integrally mounted S6A Pilot Solenoid Valve is energized the regulator controlling at the lower of two set-points, which must be adjusted on the pressure pilot over the center of the main valve. When the solenoid is de-energized the regulator is controlling at the higher set-point, which must be adjusted on the bolt-on (outboard) pressure pilot.

Purpose

The Type A4AD uses are similar to those for the A4AB except, instead of operating in a wide-open position when the pilot solenoid is energized, the regulator is controlling at some pre-set level.

Typical uses include capacity control of an evaporator at two different pressure levels to regulate temperature, and evaporator pressure control combined with defrost pressure relief.

Principles of Operation

The operation of the A4AD is similar to that described on page 1. When the Pilot Solenoid is energized, upstream pressure from passage N is made available to both diaphragms. Since the path of least resistance will be through the Pressure Pilot with the lower set-point (lower range spring force) that pilot will control.

When the Pilot Solenoid is de-energized, upstream pressure from passage N can flow only to the high pressure pilot, which will then control the regulator.

Adjustment

Electrically de-energize the solenoid pilot and adjust the modular (bolt-on) pressure pilot for the desired high pressure setting following the adjusting procedure as described above. Energize the solenoid pilot and adjust the integral pressure pilot for the desired low pressure setting following the adjusting procedure described above.

BASIC ADAPTOMODE FUNCTIONS

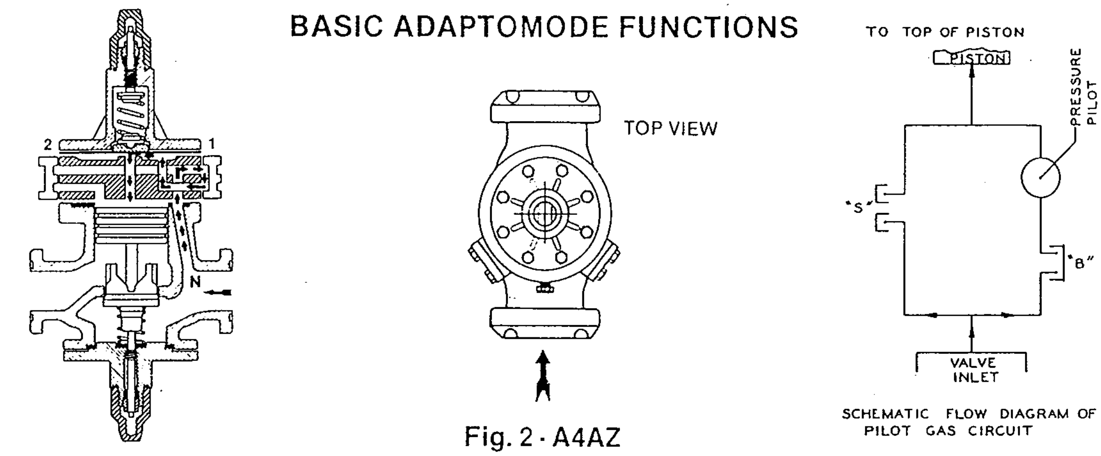


Fig. 2 · A4AZ

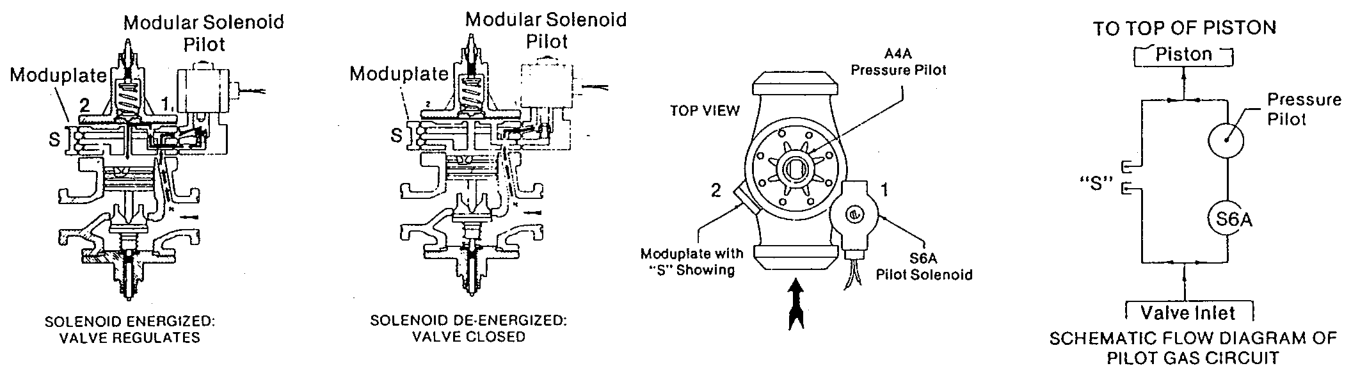


Fig. 3 · A4AS

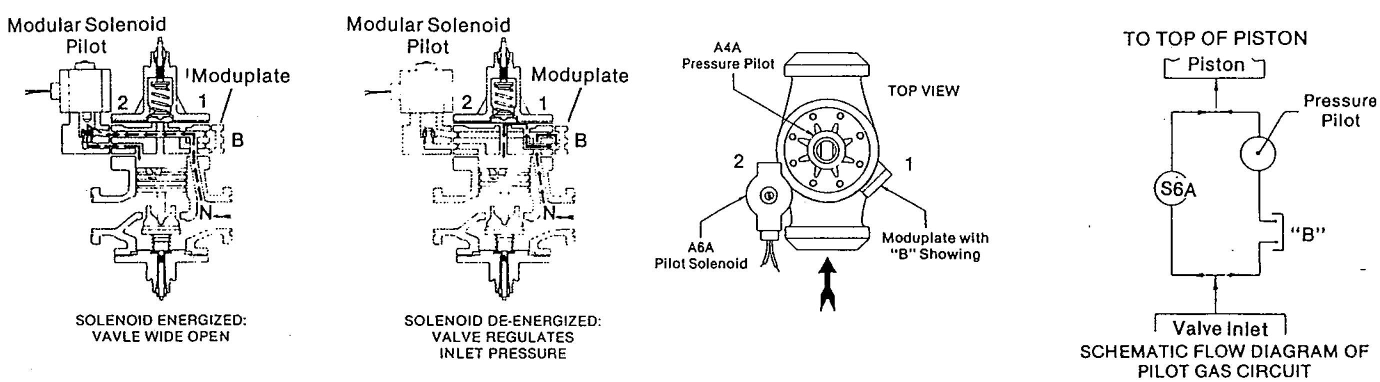


Fig. 4 · A4AB

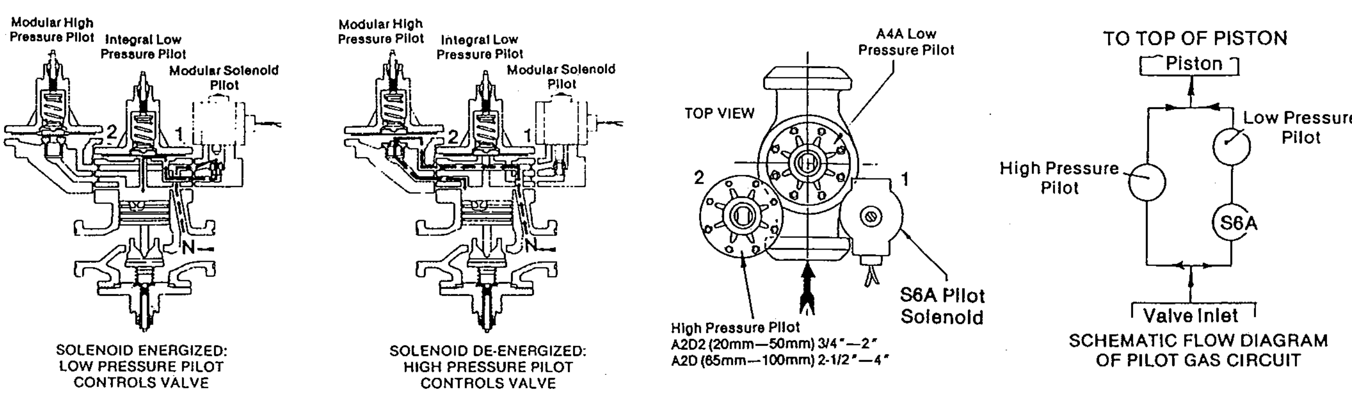


Fig. 5 · A4AD

Installation

All regulators are packed for maximum protection. Unpack carefully. Check the carton to make sure all flanges and other items are unpacked. Save the enclosed instructions for the installer and eventual user.

Do not remove the protective coverings from the inlet and outlet of the regulator until the regulator is ready to be installed. Protect the inside of the regulator from moisture, dirt and chips before and during installation. When welded or brazed flange connections are used, all slag, scale and loose particles should be removed from the flange interior before the regulator is installed between the flanges. It is advisable to install a close-coupled companion strainer (RSF) at the inlet of the regulator to help protect it from any foreign material in the system.

The A4A series of regulators will give optimum performance if mounted in a horizontal line in a vertical position with the manual opening stem on bottom. Where other positions are desired, the factory should be consulted; please give application and pipinc details. The regulator must be installed with the arrow on the valve body pointing in the direction of the fluid flow for the regulator to function properly. Backward flow through the regulator is uncontrolled and will vary with the valve model anc the reverse pressure drop encountered. The regulator is not a check valve.

Tighten the flange bolts and nuts evenly to provide proper seatin of the flange gasket and to avoid damage to gaskets or flanges (See Flange Bolt Torque Table, page 16) Avoid using the regulato flange bolts to stretch or align pipe. Even the heavy duty semi steel body of an A4A can be distorted, causing the precision parts to bind.

The regulator should be installed in a location where it is easily accessible for adjustment and maintenance. The location shoulc be such that the regulator can not be easily damaged by materia handling equipment. When it is necessary to insulate the regulator (and companion strainer), the insulation should be installed to provide access to the regulator (and companior strainer) for adjustment and maintenance. Do not insulate the solenoid coil and coil housing. Proper indicating gauges shoulc be installed to be easily visible to the operating engineer fo system checking and adjusting purposes.

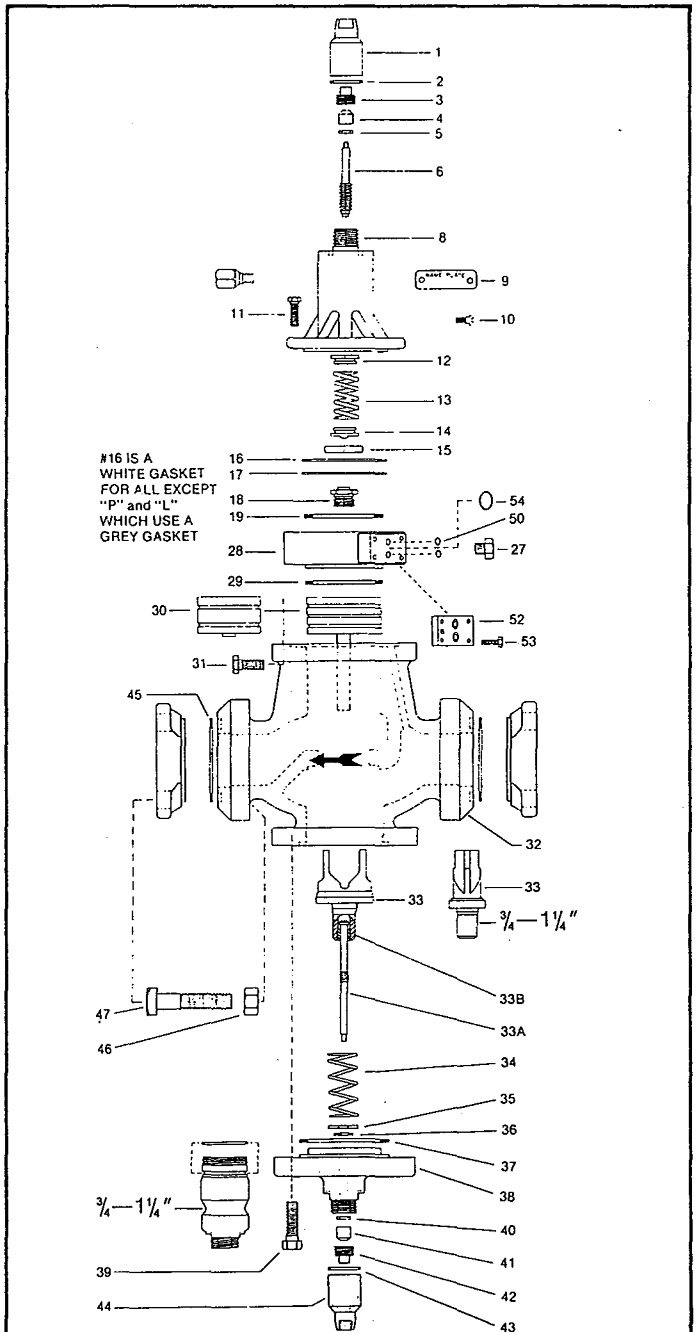


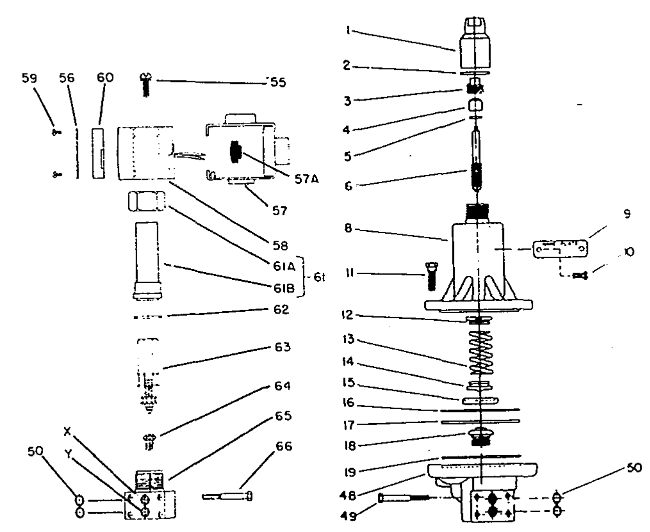
Fig. 6

Disassembly and Assembly

Refer to the exploded views, Figs. 6 and 7, in this section.

Before disassembling any A4A type regulator, read the information in this bulletin and Bulletin RSB, Safety Procedures fo Refrigerating Specialties Division Refrigeration Control Valves.

Before a regulator is removed from the line or disassembled in the line, make sure that all refrigerant has been removed from the regulator, including the bonnet where applicable, and the close coupled strainer. The regulator must be isolated from the rest o the system in a safe manner. When pumping down to remove the refrigerant, the manual opening stem 33A must be turned ou (counter clockwise) to make sure the valve is open.



S6A MODULAR SOLENOID PILOT (For A4—Port Sizes 20—100mm 3/4"—4")

A2D2, A2D MODULAR PRESSURE PILOT
A2D2 Port Sizes 20—50mm (3/4"—2")
A2D Port Sizes 65—100mm (2 1/2"—4")

Fig. 7

All A4A Regulators General Procedure

The construction of the regulator and the method of disassembly are relatively simple, but some procedures must be followed to avoid damage. The following describes the procedure for the basic A4A; special instructions for other types are included in other appropriate sections.

Disassembly — Take care when removing Seal Caps 1 and 44 in case some refrigerant may be trapped inside. Back the Adjusting Stem 6 all the way out to remove any pressure from Range Spring 13 otherwise damage to Diaphragm 17 or Pilot Seat 18 may occur. Remove Bonnet 8 by carefully removing Cap Screws 11. Take care not to damage Diaphragm Follower 15. Remove Adapter 28 by removing Cap Screws 31. Turn the Manual Opening Stem 33A all the way in until the flats on the stem barely protrude from the stuffing box nut. Push Piston 30 down against the spring force. The piston should move freely down and be returned by the spring force. If the piston is jammed or sticky, remove Bottom Cap Assembly which includes Items 33 through 42 by removing Cap Screws 39 or unscrewing Bottom Cap, 20mm through 32mm (3/4" through 1-1/4"). Using a hard wood dowel rod inserted through the bottom of the valve, tap the piston upward and out. Throughly clean all parts. If jamming has taken place and the piston and bore are scored, remove all burrs by polishing the piston, bore and throttling plug with fine crocus cloth. Inspect the seating area of the Throttling Plug 33 for damage or erosion. If damaged it should be replaced. It would be advisable to replace the entire bottom cap assembly. Inspect all gaskets and "O" rings for damage and replace where necessary.

Assembly— When reassembling the valve, all internal parts should be clean, dry and lightly oiled with refrigerant oil, except "O" rings. Apply silicone grease to the "O" rings. Care must be taken especially when the parts are cold since moisture can condense on parts and cause rapid rusting. When replacing gaskets, they should be oiled very lightly with refrigerant oil before assembly. Install bottom cap assembly first and tighten in place. Carefully replace the piston; never try to force it in place. Align the Adapter Gasket 29 carefully with the proper holes in the adapter and valve body and fasten adapter in place. Before assembling the bonnet be sure the Adjusting Stem 6 is turned all the way out and that the Bonnet 8 and Diagphragm Follower 15 are properly aligned, otherwise damage to the diaphragm and pilot seat may occur. Place Gasket 19 in the adapter and align Gasket 16 and Diaphragm 17 to the center of the bonnet. The raised center of the diaphragm must be towards the bonnet. For range "D" use two diaphragms. Tighten Cap Screws 11 evenly. The ideal tightening forque is 1.5 Kg-m (11 ft. lbs.). Valve is now ready to be adjusted for normal operation.

If close coupled strainer is used, it may be cleaned before putting the valve back in operation. The regulator must be tested for leaks with refrigerant gas or other appropriate gas before the system is put into operation.

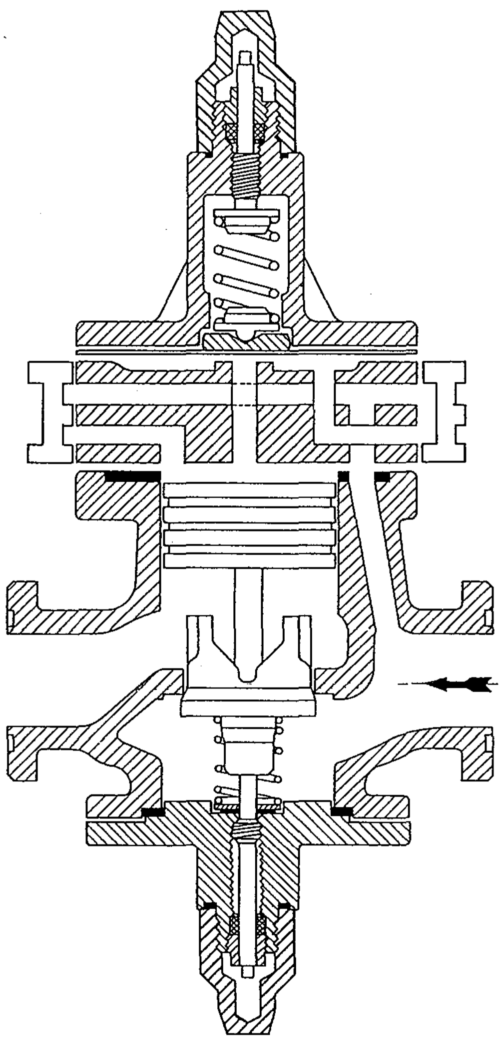
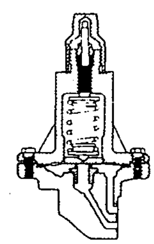
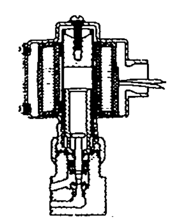


Fig. 8 - A4AZ



A2D
MODULAR PRESSURE PILOT

MODUPLATE



S6A
MODULAR SOLENOID PILOT

Fig. 9

Disassembly and Assembly (continued)

Basic Modules
Disassembly and Assembly

Refer to exploded views (Figs. 10 and 11) and also page 3 for explanation of "Basic Adaptomode Functions" to assist in clarification of module placement, as discussed in this section. Before disassembling and assembling any modules, refer to page 4 of this bulletin and to Bulletin RSB, Safety Procedure for Refrigerating Specialties Division Refrigeration Control Valves.

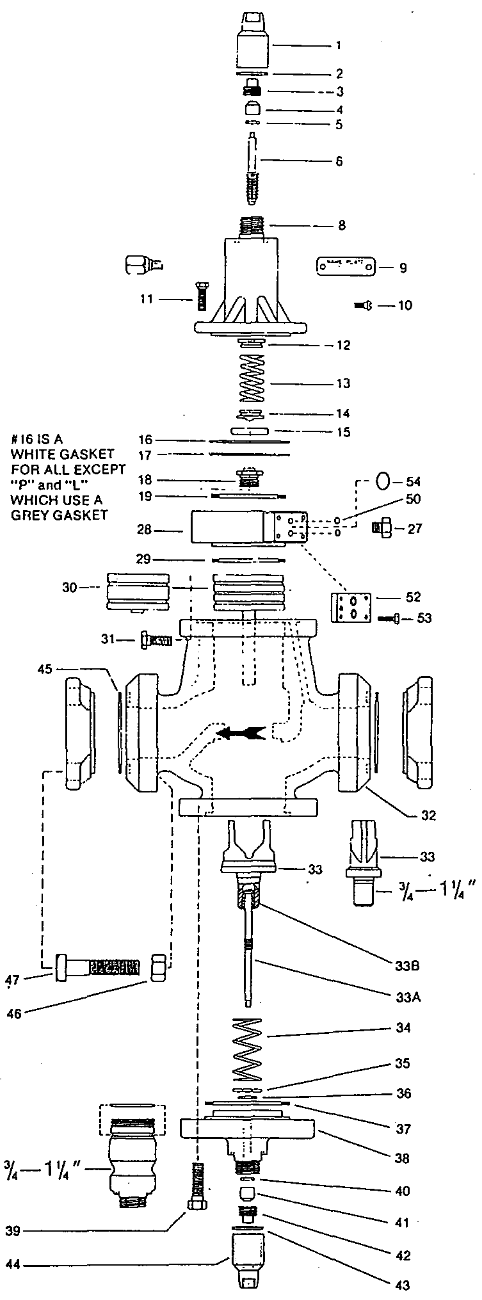


Fig. 6

Modudapter
The Modudapter 28 will accommodate the Modular Pilots and Moduplates illustrated on page 3. When assembling make sure the Modudapter gauge port is directly lined up with the inlet of the regulator. Passage N must communicate upstream pressure through the hole in Adapter Gasket 29 as well as into Modudapter 28 and thence to the pilot modules. It is imperative that proper alignment of these items be made to assure regulator function.

Before disassembly, make sure all refrigerant has been removed from the regulator and strainer, if used.

Protect the surfaces of Pads 1 and 2 of the Modudapter at all times since these surfaces determine the sealing tightness of the "O" Rings.

A2D, A2D2 Modular Pressure Pilots (Figs. 11 and 12)
These pressure pilots are used where a dual pressure regulator is desired and is mounted on Pad 2. Follow the disassembly and assembly procedure for the A4A pilot (pages 4 and 5). When mounting the pilot, place the "O" Rings 50 into the proper grooves and tighten the Cap Screws 49 evenly. The ideal tightening torque is 1.1 Kg-m (8 ft. lbs).

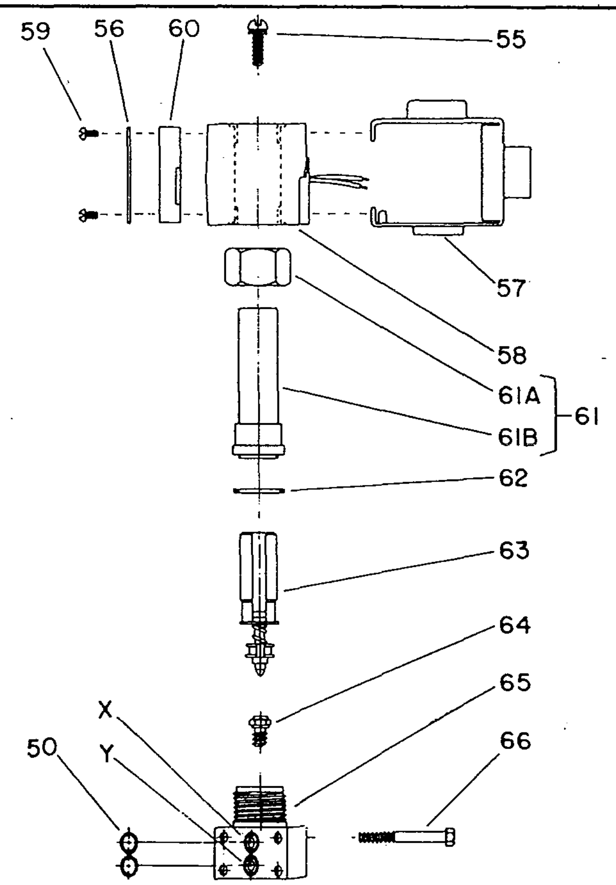
S6A Modular Solenoid Pilot (Figs. 10 and 12)
This solenoid pilot may be mounted on either Pad 1 or 2 depending on the function desired (see pages 2 and 3). Before working on any solenoid pilot, make sure the coil is de-energized and will remain so during the servicing period.

Disassembly (Fig. 10) — Remove Coil Housing Screw 55 and pull entire Coil and Housing Assembly, 56 through 60, upward and off of Bonnet-Tube Assembly 61. Carefully remove Bonnet-Tube Assembly. Lift out Plunger-Needle Assembly 63, avoid damaging the needle. Remove Seat Assembly 64 by using a 7/16" (11 mm) socket wrench. Inspect all parts, clean or replace as needed.

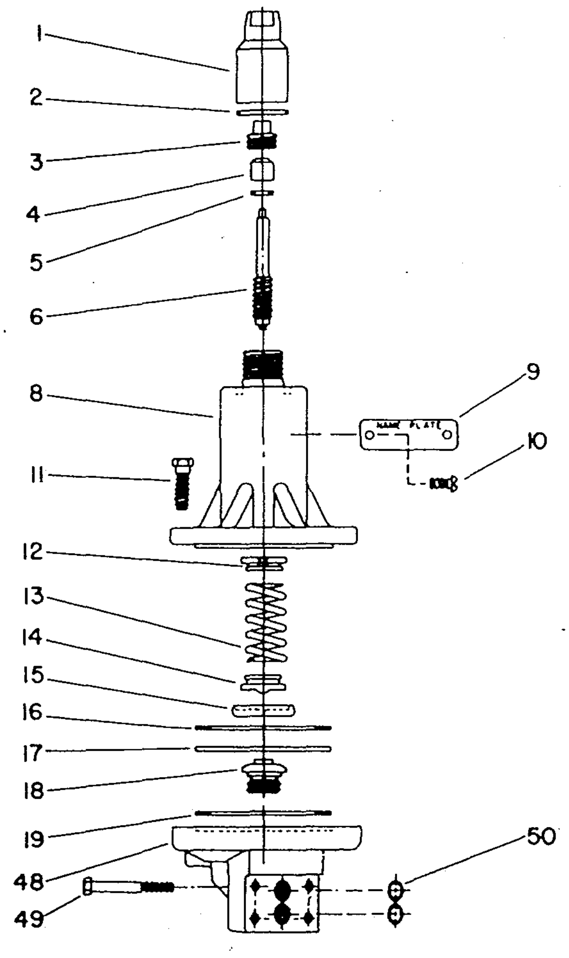
Assembly (Fig. 10) — Reinstall the Seat Assembly and tighten (no gasket needed). Carefully insert the Plunger Needle Assembly. Replace the Gasket 62 and re-install Bonnet-Tube Assembly. Replace entire Coil and Housing Assembly and tighten Coil Housing Screw.

Make sure the solenoid coil is of the proper voltage and frequency.

When mounting the solenoid pilot, place the "O" Rings 50 into the proper grooves and tighten the Cap Screws 66, evenly. The ideal tightening torque is 1.1 kg-m (8 ft. lbs.).



S6A MODULAR SOLENOID PILOT
For A4—Port Sizes 20—100mm (¾—4")
Fig. 10



A2D2, A2D MODULAR
PRESSURE PILOT

A2D2 For A4—Port sizes 20—50mm (3/4"—2")
A2D For A4—Port sizes 65—100mm (2½"—4")
Fig. 11

Moduplate (Figs. 6 and 12)
These Moduplates 52 are used to direct the flow or stop the flow through the flow paths of the Modudapter. Protect the "O" Ring surfaces at all times. When mounting the Moduplate, place "O" Rings 50 (or "O" Ring 54) into the proper grooves (lubricate with silicone grease) and tighten the Cap Screws 53 evenly to avoid distortion and assure proper sealing. The ideal tightening torque is 1.1 Kg-m (8 ft. lbs.).

Maintenance and Service

General Procedure:

Before disassembly of regulator, make certain that all refrigerant has been removed (pumped out) from the regulator and its companion strainer where one is used. Read Safety Bulletin RSB.

Dirt in the system is the greatest single cause of regulator malfunction. All screens or filters must be cleaned or replaced when they become dirty. At start up it is especially important that these items are cleaned or changed frequently. When the RSF close-coupled companion strainers are used, maintain according to instructions in Bulletin 00-10. Moisture in halocarbon systems in particular can cause corrosion or form ice, causing the piston to freeze in position. Filter-driers should be used and maintained for halocarbon systems.

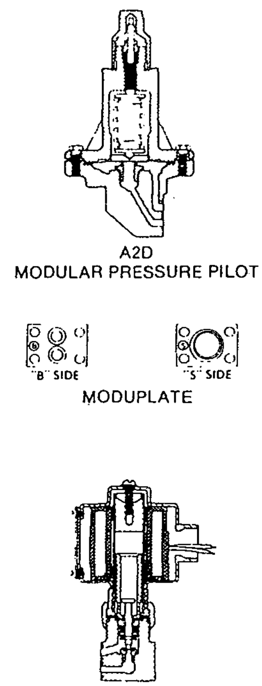
Before deciding to disassemble a regulator for servicing, the following investigations should be made:

Check the manual opening stem; it should be turned in for automatic operation.

Check the regulator setting to make sure it is properly adjusted. Turn adjusting screw slowly to see if regulator responds. Check regulator pressure range; if wrong, range spring must be replaced.

Check other system components for proper operation. Make sure that the regulator receives the proper electrical signal where modular pilot solenoids are used. Make sure they are same as the power supply.

Check hand valves in the system to make sure they are open or closed as required and the system is receiving liquid or gas as the case may be.



A2D
MODULAR PRESSURE PILOT

MODUPLATE

S6A
MODULAR SOLENOID PILOT

Fig. 12

Solenoid Coils and Coil Housing

The solenoid coils and coil housing, identified and described on page 8 for the Type S6A Solenoid Pilot, are an improved design which provide a higher MOPD and a cooler coil resulting in longer life. The new coil and its heavily plated; rust resisting housing are interchangeable with the obsolete coil and cast iron housing as follows: The new coil, which has its Part Number stamped on the side, can be used in both the old and new coil housing; the old coil which has its 30-0030-XX Series Part Number stamped on one end, can be used in the old, cast iron housing only. There is no bottom marking on the new coil; either end may be positioned up. The color coding of lead wires for various voltage and frequencies has not been changed. The fuses used with the old coils are suitable for the new coils; the new coil power consumption is 33 Watts instead of 37.

The S6A pilot solenoid valve is also available with a coil using a quick electrical connector or plug, permitting easy wiring connection with an exposed rubber covered cable instead of a rigid or flexible conduit and enclosed wiring. This type of coil cannot be used with the old, cast iron housing.

The new coils and new housing described above for the S6A valve are also used with Solenoid Valve Types S4, S5, S6N, S7, S8 and S9.

Electrical

The Refrigerating Specialties Division molded water resistan Class "B" solenoid coil is designed for long life and powerful opening force. The standard coil housing meets NEMA 3R and 4 requirements. This sealed construction can withstand direct contact with moisture and ice. The coil housing far exceeds the requirements of NEMA Standard ICS, 1-110.57 salt spray test for rust resistance.

By definition, Class "B" coil construction will permit coil temperatures, as measured by resistance method, as high as 130 °C (266 °F). Final coil temperatures are a function of both fluid and ambient temperatures. The higher fluid temperatures require lower ambient temperatures so the maximum coil temperature is not exceeded. Conversely, low fluid temperatures permit higher ambient temperatures.

The molded Class "B" coil is available from stock with most standard voltages. However, coils are available for other voltages and frequencies, as well as for direct current. Coils are also avilable as transformer type with a 6 volt secondary winding for use with the Refrigerating Specialties Division Pilot Light Assembly (see current copy of Bulletin 60-10, "Pilot Light Assembly and Solenoid Transformer Coil").

The solenoid coil must be connected to electrical lines with volts and Hertz same as stamped on coil. The supply circuits must be properly sized to give adequate voltage at the coil leads even when other electrical equipment is operating. The coil is designed to operate with line voltage from 85% to 110% of rated coil voltage. Operating with a line voltage above or below these limits may result in coil burn-out. Also, operating with line voltage below the limit will definitely result in lowering the valve opening pressure differential. Power consumption during normal operation will be 33 watts or less.

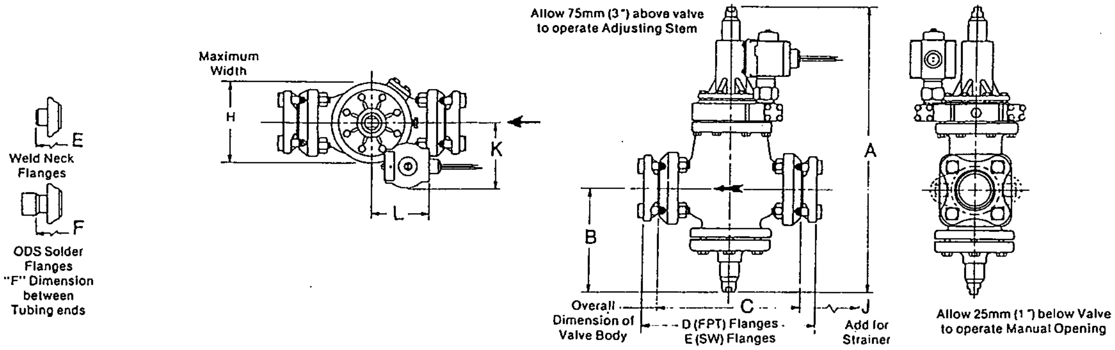
Inrush and running current is listed below:

Standard Coil Volts/Hertz	Part Number	Inrush Current (Amps)	Running Current (Amps)	Fuse Size (Amps)
120/60 (Blue leads)	200917	1.60	0.52	1
208/60 (Blue & Red leads)	200921	0.88	0.28	1
240/60 (Red leads)	200918	0.86	0.26	1
440/60 (Yellow & Red leads)	200927	0.39	0.13	1
115/50 (Yellow & Blue leads)	200925	1.50	0.46	1
230/50 (Yellow leads)	200922	0.92	0.26	1
Other		(Contact Factory)		

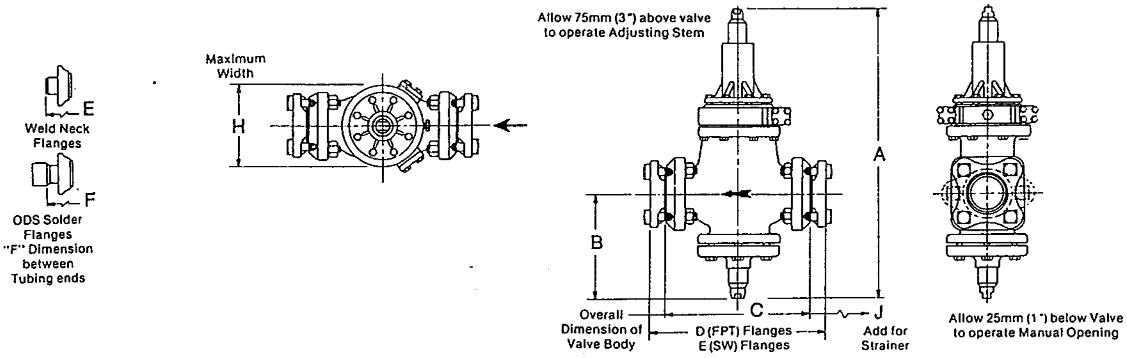
On transformer coil the 6 volt leads are always black.

SERVICE POINTERS (Check General Procedure)

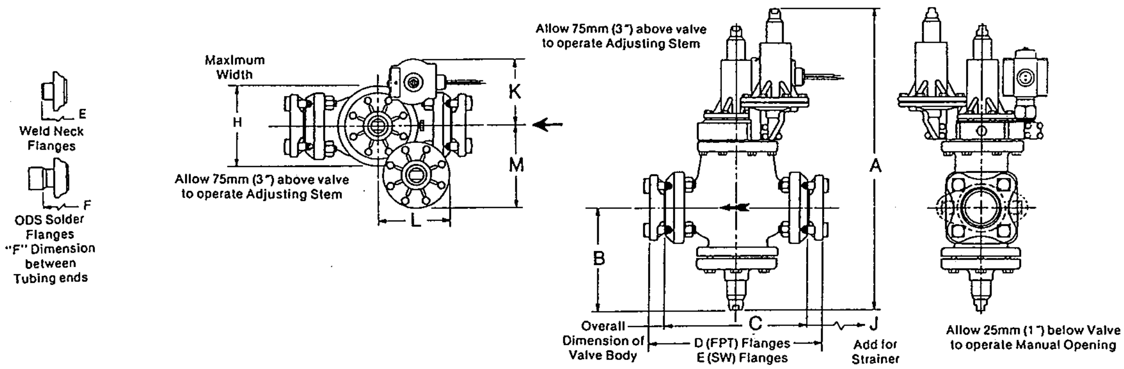
SYMPTOM	PROBABLE REASON	CORRECTION
Regulator does not shut off flow.	Diaphragm or seat dirty, damaged or frozen.	Clean or replace. Clean strainer.
	Diaphragm follower stuck or damged.	Clean or replace. Install follower carefully.
	Piston jammed with excess dirt.	Remove and polish piston and bore with crocus cloth. Clean valve and strainer.
	Throttling plug leaking due to excess dirt or damage.	Clean or replace. If used on liquid, check for erosion due to excessive flash gas. Reduce flash gas by subcooling or by reducing pressure drop across valve by providing restriction at valve outlet.
	Diaphragm ruptured or badly deformed.	Replace. If Range "D" make sure has 2 diaphragms.
	A4AB Modular Solenoid Pilot seat leaking.	Check seat and needle. Replace as needed.
	A4AS Modular Solenoid Pilot seat leaking.	Check seat and needle. Replace as needed.
	Diaphragm and seat eroded due to flash gas.	Replace. Reduce flash gas by subcooling or by reducing pressure drop across regulator by providing restriction at valve outlet.
	Modular Solenoid Pilot not closing.	Check power at leads, make sure coil is de-energized.
Regulator does not open.	A4A (inlet) Pressure Regulator Diaphragm ruptured or badly deformed.	Replace. If Range D make sure has 2 diaphragms.
	Diaphragm follower stuck, damaged or frozen.	Clean or replace. Install follower carefully.
	A4AS/A4AB Modular Solenoid Pilot not opening.	Pressure drop across valve too high; over 21 bar (300 psig). Lower pressure drop. Improper power supply. Correct. Replace solenoid coil.
	Piston worn, too much clearance.	Replace piston. Check for reason. If used on liquid, check for flash gas.
Regulator Operation erratic.	Diaphragm or seat dirty or damaged.	Clean or replace. Clean strainer.
	Diaphragm follower has dirt on the outside diameter or outside diameter is damaged.	Clean or replace.
	Other system components, line controllers, thermostats, etc., erratic.	Adjust, repair or replace.
	Regulator too far oversized.	Check load. Replace with smaller regulator or investigate use of reduced capacity plug.
Pressure drop across regulator too high.	Inlet or outlet restricted.	Check for restriction. Clean strainer.
	Regulator too small.	Open manually to be sure valve is full open. Replace with proper size regulator.
	Large amount of flash gas in liquid line.	Reduce flash gas by subcooling. Reduce line restriction by increasing line size, particularly at the regulator outlet. Replace with larger regulator.
	High pressure drop causes high rate of expansion of gas at regulator outlet.	Increase pipe size at the outlet of the regulator.
	Regulator does not open all the way.	Check piston for wear. Replace, if needed.



A4AB, S



A4AZ



A4AD

TABLE OF DIMENSIONS FOR INLET PRESSURE REGULATOR Types A4AS, A4AB, A4AD and A4AZ																Types A4AS, A4AB & A4AZ 100 mm (4")			Type A4AD Only 100 mm (4")		
TYPE	20 mm & 25MM (3/4 & 1")			32 mm (1-1/4")			40 mm & 50MM (1-5/8 & 2")			65 mm (2-1/2")			75 mm (3")								
DIMENSIONS		mm	Inches		mm	Inches		mm	Inches		mm	Inches		mm	Inches		mm	Inches		mm	Inches
A		429	16.9"		447	17.6"		500	19.7"		513	20.2"		632	24.9"		685	27.0"		685	27.0"
B		148	5.8"		162	6.3"		177	6.9"		181	7.1"		273	10.7"		292	11.5"		292	11.5"
C		164	6.2"		203	8.0"		251	9.9"		251	9.9"		311	12.2"		339	14.1"		339	14.1"
(D)	1/2"	216	8.5"	1-1/4"	256	10.1"	1-1/2"	307	12.1"	2-1/2"	331	13.0"	3"	389	15.3"	4"	450	17.7"	4"	450	17.7"
(F.P.T.) FOR	3/4"	216	8.5"																		
PIPE SIZES	1"	216	8.5"	1-1/2"	256	10.1"	2"	307	12.1"												
SHOWN	1-1/4"	216	8.5"																		
(E)	1/2"	216	8.5"	1-1/4"	256	10.1"	1-1/2"	307	12.1"	2-1/2"	331	13.0"	3"	389	15.3"	4"	450	17.7"	4"	450	17.7"
(S.W.) FOR	3/4"	216	8.5"																		
PIPE SIZES	1"	216	8.5"	1-1/2"	256	10.1"	2"	307	12.1"												
SHOWN	1-1/4"	216	8.5"																		
(F)	—	—	—	1-1/4"	300	11.8"	1-1/2"	364	14.3"	2-1/2"	401	15.6"	3"	478	18.8"	4"	571	22.5"	4"	571	22.5"
(W.N.) FOR	3/4"	254	10.0"																		
PIPE SIZES	1"	261	10.3"	1-1/2"	304	12.0"	2"	371	14.6"												
SHOWN	1-1/4"	261	10.3"																		
(G)	7/8"	239	9.4"	1-3/8"	269	10.6"	1-5/8"	358	14.1"	2-5/8"	348	13.7"	3-1/8"	414	16.3"						
(O.D.S.) FOR	1-1/8"	239	9.4"	1-5/8"	279	11.0"	2-1/8"	338	13.3"							4-1/8"	503	19.8"	4-1/8"	503	19.8"
TUBE SIZES	1-3/8"	231	9.1"	2-1/8"	305	12.0"	2-5/8"	358	14.1"	3-1/8"	389	15.3"	3-5/8"	432	17.0"						
SHOWN	1-5/8"	239	9.4"																		
H		117	4.6"		117	4.6"		140	5.5"		159	6.2"		178	7.0"		222	8.8"		222	8.8"
J		98	3.9"		178	7.0"		251	9.9"		314	12.4"		314	12.4"		363	14.3"		363	14.3"
K		112	4.4"		112	4.4"		117	4.6"		124	4.9"		142	5.6"		157	6.2"		157	6.2"
L		122	4.8"		122	4.8"		135	5.3"		133	5.2"		122	4.8"		152	6.0"		140	5.5"
M		138	5.4"		138	5.4"		140	5.5"		150	5.9"		170	6.6"					190	7.7"

Repair Kits for A4AZ, A4AS, A4AB and A4AD

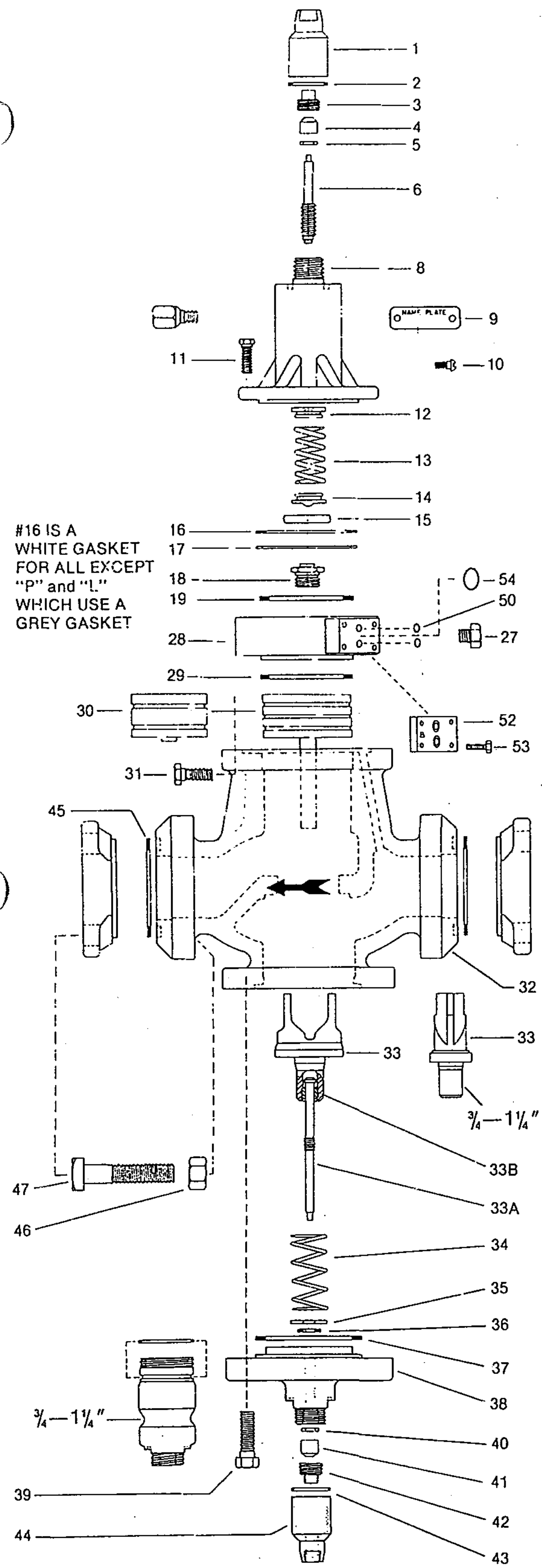


Fig. 6 - A4AZ

Item No.	Description		20mm (3/4") Kit No.	Qty	25mm (1") Kit No.	Qty
1	Seal Cap		Only Avail. with Kit	1	Only Avail. with Kit	1
2	Seal Cap Gasket		Only Avail. with Kit	1	Only Avail. with Kit	1
1-2	Cap Kit, Seal		202110	1	202110	1
3	Nut, Packing		Only Avail. with Kit	1	Only Avail. with Kit	1
4	Packing, Stem		Only Avail. with Kit	1	Only Avail. with Kit	1
5	Washer, Flat		Only Avail. with Kit	1	Only Avail. with Kit	1
3-5	Packing Kit, Stem		202100	1	202100	1
6	Stem, Adjusting		Only Avail. with Kit	1	Only Avail. with Kit	1
4-6	Stem Kit, Adjusting		202120	1	202120	1
12	Plate, Spring, Upper		Only Avail. with Kit	1	Only Avail. with Kit	1
13	Spring, Comp.		Only Avail. with Kit	1	Only Avail. with Kit	1
14	Plate, Spring, Lower		Only Avail. with Kit	1	Only Avail. with Kit	1
15	Follower, Diaphragm		Only Avail. with Kit	1	Only Avail. with Kit	1
3-5, 6,	Spring/	Rge. A/V	202006	1	202006	1
12-15	Stem Kit	Rge. D	202007	1	202007	1
8	Bonnet		Only Avail. with Kit	1	Only Avail. with Kit	1
11	Screw, Hx.Hd.		Only Avail. with Kit	8	Only Avail. with Kit	8
16	Bonnet Gasket		Only Avail. with Kit	1	Only Avail. with Kit	1
1-6, 8,	Spring Kit	Rge. A/V	202008	1	202008	1
11-16	with Bonnet	Rge. D	202009	1	202009	1
12-14,	Spring Kit,	Rge. A/V	202481	1	202481	1
16	less Bonnet	Rge. D	202482	1	202482	1
17	Diaphragm		Only Avail. with Kit	1	Only Avail. with Kit	1
19	Gasket		Only Avail. with Kit	1	Only Avail. with Kit	1
16, 17, 19	Diaphragm Kit	Rge. A/V	200770	1	200770	1
17	Diaphragms	Rge. D	Only Avail. with Kit	2	Only Avail. with Kit	2
16, 17, 19	Diaphragm Kit	Rge. D	200771	1	200771	1
16-19	VC Vacuum Cartridge		Only Avail. with Kit	1	Only Avail. with Kit	1
16, 18, 19	Seat, Pilot	Rge. A	200410	1	200410	1
		Rge. V	202004	1	202004	1
		Rge. D	200410	1	200410	1
	Pilot Seat/	Rge. A	202000	1	202000	1
16-19	Diaphragm Kit	Rge. V	202004	1	202004	1
	(Not A4AL or A4AO)	Rge. D	202002	1	202002	1
16-19	Pilot Seat/Diaphragm Kit (A4AL Only)	Rge. A	202497	1	202497	1
27	Plug Pkg, 1/4" NPT		202552	5	202552	5
28	Adapter		Only Avail. with Kit	1	Only Avail. with Kit	1
29	Gasket		Only Avail. with Kit	1	Only Avail. with Kit	1
19, 28, 29	Adapter Kit		200703	1	200703	1
30	Piston/Stem Assembly		Only Avail. with Kit	1	Only Avail. with Kit	1
29, 30	Piston Kit		200760	1	200760	1
32	Valve Body		Not Available		Not Available	
34	Spring, Comp.		Only Avail. with Kit	1	Only Avail. with Kit	1
35	Washer, Flat		Only Avail. with Kit	1	Only Avail. with Kit	1
36	Wiper, Dirt		Only Avail. with Kit	1	Only Avail. with Kit	1
37	"O" Ring		Only Avail. with Kit	1	Only Avail. with Kit	1
34-37	Spring Kit,	(A4A)	202300	1	202300	1
	Closing	(A4AK)	202298	1	202298	1
33	Plug/Stem Assembly		Only Avail. with Kit	1	Only Avail. with Kit	1
40	Washer, Flat		Only Avail. with Kit	1	Only Avail. with Kit	1
41	Packing, Stem		Only Avail. with Kit	1	Only Avail. with Kit	1
42	Nut, Packing		Only Avail. with Kit	1	Only Avail. with Kit	1
33, 34-37,	Full Cap. Plug	(A4A)	202021	1	202022	1
40-42	Kit, Modul.	(A4AK)	202037	1	202038	1
33, 34-37,	50% Cap. Plug	(A4A)	202029	1	(*)	
40-42	Kit, Modul.	(A4AK)	202036	1	(*)	
33, 34-37,	35% Cap. Plug	(A4A)	Not Available		Not Available	
40-42	Kit, Modul.	(A4AK)	Not Available		Not Available	
33, 34-37,	17% Cap. Plug	(A4A)	202030	1	(*)	
40-42	Kit, Modul.	(A4AK)	202030	1	(*)	

(*) All Plug Kits and Bottom Assembly Kits for 3/4" Port Size Valves can be used in the 1" Port Size Valves for reducing capacity.
(**) All Plug Kits and Bottom Assembly Kits for 1-5/8" Port Size Valves can be used in the 2" Port Size Valves for reducing capacity.

Item No.	32mm (1-1/4") Kit No.	Qty	40mm (1-5/8") Kit No.	Qty	50mm (2") Kit No.	Qty	65mm (2-1/2") Kit No.	Qty	75mm (3") Kit No.	Qty	100mm (4") Kit No.	Qt
1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
2	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
1-2	202110	1	202110	1	202110	1	202110	1	202110	1	202110	1
3	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
4	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
5	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
3-5	202100	1	202100	1	202100	1	202100	1	202100	1	202100	1
6	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
4-6	202120	1	202120	1	202120	1	202120	1	202120	1	202120	1
12	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
13	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
14	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
15	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
3-5, 6,	202006	1	202006	1	202006	1	202006	1	202006	1	202006	1
12-15	202007	1	202007	1	202007	1	202007	1	202007	1	202007	1
8	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
11	Only Avail. with Kit	8	Only Avail. with Kit	8	Only Avail. with Kit	8	Only Avail. with Kit	8	Only Avail. with Kit	8	Only Avail. with Kit	8
16	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
1-6, 8,	202008	1	202008	1	202008	1	202008	1	202008	1	202008	1
11-16	202009	1	202009	1	202009	1	202009	1	202009	1	202009	1
12-14,	202481	1	202481	1	202481	1	202481	1	202481	1	202481	1
16	202482	1	202482	1	202482	1	202482	1	202482	1	202482	1
17	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
19	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
16, 17, 19	200770	1	200770	1	200770	1	200770	1	200770	1	200770	1
17	Only Avail. with Kit	2	Only Avail. with Kit	2	Only Avail. with Kit	2	Only Avail. with Kit	2	Only Avail. with Kit	2	Only Avail. with Kit	2
16, 17, 19	200771	1	200771	1	200771	1	200771	1	200771	1	200771	1
16-19	Only Avail. with Kit	1	Only Avail. with Kit	1	202004	1	202004	1	202004	1	202004	1
16, 18, 19	200410	1	200410	1	200410	1	200411	1	200411	1	200411	1
	202004	1	202004	1	202004	1	202004	1	202004	1	202004	1
	200410	1	200410	1	200410	1	200411	1	200411	1	200411	1
	202000	1	202000	1	202000	1	202001	1	202001	1	202001	1
16-19	202004	1	202004	1	202004	1	202004	1	202004	1	202004	1
	202002	1	202002	1	202002	1	202003	1	202003	1	202003	1
16-19	202497	1	202497	1	202497	1	202499	1	202499	1	202499	1
27	202552	5	202552	5	202552	5	202552	5	202552	5	202552	5
28	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
29	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
19, 28, 29	200700	1	200725	1	200725	1	200685	1	200713	1	200716	1
30	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
29, 30	200767	1	200389	1	200389	1	200391	1	200393	1	200227	1
32	Not Available		Not Available		Not Available		Not Available		Not Available		Not Available	
34	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
35	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
36	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
37	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
34-37	202301	1	202302	1	202302	1	202303	1	202304	1	202305	1
	202299	1	202302	1	202302	1	202303	1	202304	1	202305	1
33	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
40	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
41	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
42	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1
33, 34-37,	202023	1	202024	1	202025	1	202026	1	202027	1	202028	1
40-42	202039	1	202024	1	202025	1	202026	1	202027	1	202028	1
33, 34-37,	Not Available		Not Available		Not Available		Not Available		Not Available		Not Available	
40-42	Not Available		Not Available		Not Available		Not Available		Not Available		Not Available	
33, 34-37,	202031	1	202032	1	(**)		202033	1	202034	1	202035	1
40-42	202031	1	202032	1	(**)		202033	1	202034	1	202035	1
33, 34-37,	Not Available		Not Available		Not Available		Not Available		Not Available		Not Available	
40-42	Not Available		Not Available		Not Available		Not Available		Not Available		Not Available	

(*) All Plug Kits and Bottom Assembly Kits for 3/4" Port Size Valves can be used in the 1" Port Size Valves for reducing capacity.

(**) All Plug Kits and Bottom Assembly Kits for 1-5/8" Port Size Valves can be used in the 2" Port Size Valves for reducing capacity.

Repair Kits for A4AZ, A4AS, A4AB and A4AD

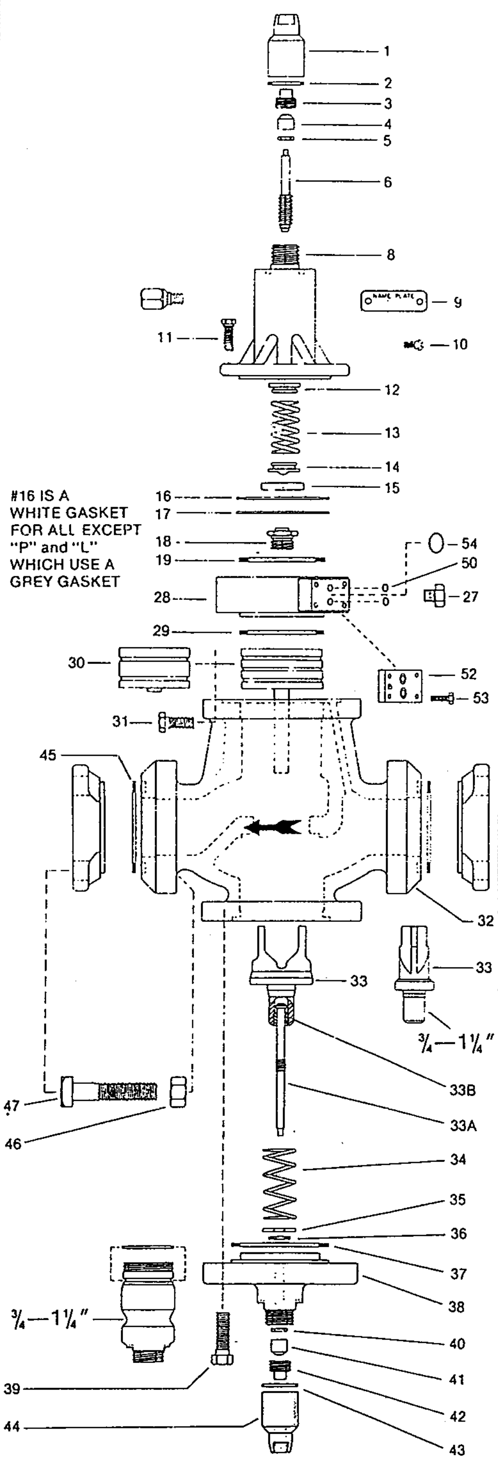


Fig. 6 - A4AZ

Item No.	Description		20mm (3/4") Kit No.	Qty	25mm (1") Kit No.	Qty
37	"O" Ring		Only Avail. with Kit	1	Only Avail. with Kit	1
38	Cover, Bottom		Only Avail. with Kit	1	Only Avail. with Kit	1
40	Washer, Flat		Only Avail. with Kit	1	Only Avail. with Kit	1
41	Packing, Stem		Only Avail. with Kit	1	Only Avail. with Kit	1
37, 38, 40, 41	Cover Kit		200761	1	200761	1
42	Nut, Packing		Only Avail. with Kit	1	Only Avail. with Kit	1
40-42	Packing Kit, Stem		202100	1	202100	1
43	Gasket		Only Avail. with Kit	1	Only Avail. with Kit	1
44	Seal Cap		Only Avail. with Kit	1	Only Avail. with Kit	1
43, 44	Seal Cap, Kit		202110	1	202110	1
33-38, 40-44	Full Cap. Bottom Assembly Kit	A4A	202010	1	202011	1
		A4AK	202018	1	202019	1
33-38, 40-44	50% Cap. Bottom Assembly Kit	A4A	202347	1	(*)	1
		A4AK	202348	1	(*)	1
33-38, 40-44	17% Cap. Bottom Assembly Kit	A4A	202346	1	(*)	1
		A4AK	Not Available		Not Available	
3-6, 12-19, 29, 30, 33-37, 40-42	Full Cap. Repair Kit, Reg. (All except A4AK)	Rge. A	202041	1	202044	1
		Rge. V	202040	1	202043	1
		Rge. D	202042	1	202045	1
3-6, 12-19, 29-30, 33-37, 40-42	50% Cap. Repair Kit, Reg. (All except A4AK)	Rge. A	202352	1	(*)	1
		Rge. V	202354	1	(*)	1
		Rge. D	202353	1	(*)	1
3-6, 12-19, 29-30, 33-37, 40-42	17% Cap. Repair Kit, Reg. (All except A4AK)	Rge. A	202349	1	(*)	1
		Rge. V	202351	1	(*)	1
		Rge. D	202350	1	(*)	1
112	Cover, Top		Only Avail. with Kit	1	Only Avail. with Kit	1
29, 112	A4AR Cover Kit		200680	1	200680	1
2, 16(2), 19(2), 25, 26, 29, 37, 43, 45(3)	**Gasket Kits (Includes complete set of gaskets plus "O" Rings if applicable)**					
	Gasket Kit A4/S4		202112		202112	
	Indv'l Gaskets, "O" Rings & Valve Pk'g sold & pkgd in qtys only as indicated.					
29	Gasket Pkg, Adapter		202406	5	202406	5
37	"O" Ring/Gasket Pkg, Bottom Cap		202384	3	202384	3
43	Gasket Pkg, Seal Cap (Bottom)		202408	12	202408	12
2	Gasket Pkg, Seal Cap (Top)		202408	12	202408	12
45	Gasket Pkg, Flange		202079	12	202079	12
4	Packing Pkg, Stem (Top)		202478	25	202478	25
41	Packing Pkg, Stem (Bottom)		202478	25	202478	25
	Bolt Package Kits					
11	Bolt Package, A4A Bonnet		202246	8	202246	8
31	Bolt Package, Adapter		202248	8	202249	8
39	Bolt Package, Bottom Cap		Not Required		Not Required	
	Flange Bolt Package includes bolts and nuts; no gaskets					
46	Nut		5/8"-11	2	5/8"-11	2
47	Bolt		5/8"-11x3"	2	5/8"-11x3"	2
46, 47	Bolt Kit, Flange		201585	1	201585	1
50, 52-54	Moduplate Kit "MP"		200518		200518	
52	Moduplate		Only Avail. with Kit	1	Only Avail. with Kit	1
54	O-Ring, "B"		Only Avail. with Kit	1	Only Avail. with Kit	1
50	O-Ring, "S", "D"		Only Avail. with Kit	2	Only Avail. with Kit	2

Flange Kit	FK-25				FK-25			
Specify Flange, Style, Connection, Size	FPT, SW, WN		ODS		FPT, SW, WN		ODS	
Kit includes 2 Flanges only	St'd	Also Avail.	St'd	Also Avail.	St'd	Also Avail.	St'd	Also Avail.
Connections Available Sizes in Inches	3/4	1, 1¼	⅞	1⅛, 1⅜	1	¾, 1¼	1⅛	1⅜, 1⅝

(*) All Plug Kits and Bottom Assembly Kits for 3/4" Port Size Valves can be used in the 1" Port Size Valves for reducing capacity.

Item No.	32mm (1-1/4") Kit No.	Qty	40mm (1-5/8") Kit No.	Qty	50mm (2") Kit No.	Qty	65mm (2-1/2") Kit No.	Qty	75mm (3") Kit No.	Qty	100mm (4") Kit No.
37	Only Avail. with Kit	1									
38	Only Avail. with Kit	1									
40	Only Avail. with Kit	1									
41	Only Avail. with Kit	1									
37, 38, 40, 41	200761	1	Not Available		Not Available		Not Available		Not Available		Not Available
42	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit
40-42	202100	1	202100	1	202100	1	202100	1	202101	1	202101
43	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit
44	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit
43, 44	202110	1	202110	1	202110	1	202110	1	202111	1	202111
33-38,	202012	1	202013	1	202014	1	202015	1	202016	1	202017
40-44	202020	1	202013	1	202014	1	202015	1	202016	1	202017
33-38, 40-44	Not Available		Not Available		Not Available		Not Available		Not Available		Not Available
33-38, 40-44	Not Available		Not Available		Not Available		Not Available		Not Available		Not Available
3-6, 12-19,	202047	1	202050	1	202053	1	202056	1	202059	1	202062
29, 30, 33-37,	202046	1	202049	1	202052	1	202055	1	202058	1	202061
40-42	202048	1	202051	1	202054	1	202057	1	202060	1	202063
3-6, 12-19, 29-30, 33-37, 40-42	NOTE: 50% Capacity Repair Kit is not available for port sizes 1-1/4" to 4". Capacity reduction can be obtained through use of field installing "Reduced Capacity Plug Kits". See description and contents of these kits elsewhere this section.										
3-6, 12-19, 29-30, 33-37, 40-42	NOTE: 17% Capacity Repair Kit is not available for port sizes 1-1/4" to 4". Capacity reduction can be obtained through use of field installing "Reduced Capacity Plug Kits". See description and contents of these kits elsewhere this section.										
112	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit
29, 112	200669	1	200673	1	200673	1	200690	1	200676	1	200677
	Gasket Kits (Includes complete set of gaskets plus "O" Rings if applicable)										
2, 16(2), 19(2), 25, 26, 29, 37, 43, 45(3)	202113		202114		202114		202115		202116		202117
	Individual Gaskets, "O" Rings and Valve Packing sold and packaged in quantities only as indicated.										
29	202407	5	202397	3	202397	3	202396	3	202399	3	202400
37	202384	3	202374	6	202374	6	202374	6	202382	3	202383
43	202408	12	202408	12	202408	12	202408	12	202404	5	202404
2	202408	12	202408	12	202408	12	202408	12	202408	12	202408
45	202080	12	202081	12	202081	12	202082	12	202083	12	202084
4	202478	25	202478	25	202478	25	202478	25	202478	25	202478
41	202478	25	202478	25	202478	25	202478	25	202479	5	202479
	Bolt Package Kits										
11	202246	8	202246	8	202246	8	202246	8	202246	8	202246
31	202248	8	202249	8	202249	8	202249	8	202250	6	202250
39	Not Required		202251	6	202251	6	202251	6	202252	6	202252
	Flange Bolt Package includes bolts and nuts; no gaskets										
46	5/8"-11	4	5/8"-11	4	5/8"-11	4	3/4"-10	4	3/4"-10	4	7/8"-9
47	5/8"-11x2-3/4"	4	5/8"-11x3-1/4"	4	5/8"-11x3-1/4"	4	3/4"-10x3-3/4"	4	3/4"-10x3-3/4"	4	7/8"-9x4-1/2"
46, 47	...201595	1	201604	1	201604	1	201611	1	201611	1	201620
50, 52-54	200518		200518		200518		200518		200518		200518
52	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit
54	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit	1	Only Avail. with Kit
50	Only Avail. with Kit	2	Only Avail. with Kit	2	Only Avail. with Kit	2	Only Avail. with Kit	2	Only Avail. with Kit	2	Only Avail. with Kit

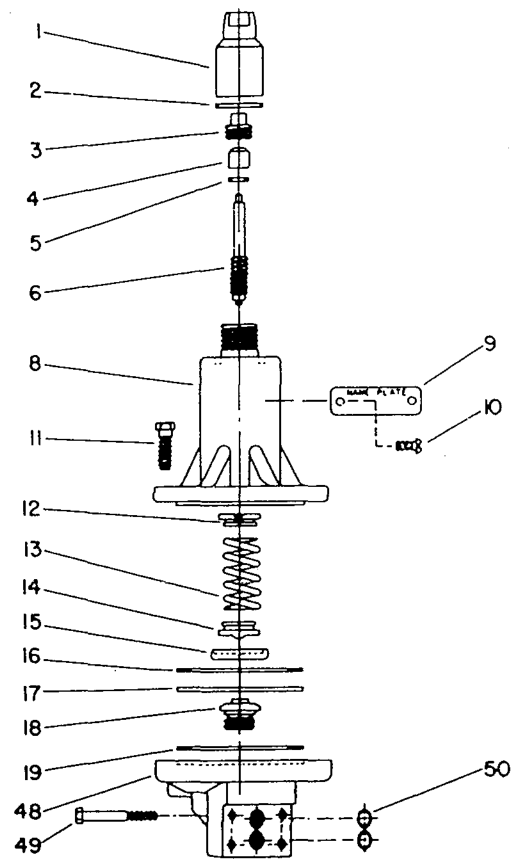
	FK-32				FK-40				FK-50				FK-65				FK-75				FK-100		
	FPT, SW, WN		ODS		FPT, SW, WN		ODS		FPT, SW, WN		ODS		FPT, SW, WN		ODS		FPT, SW, WN		ODS		FPT, SW, WN		OD
	St'd	Also Avail.	St'd	Also Avail.	St'd	Also Avail.	St'd	Also Avail.	St'd	Also Avail.	St'd	Also Avail.	St'd	Also Avail.	St'd	Also Avail.	St'd	Also Avail.	St'd	Also Avail.	St'd	Also Avail.	St'd
	1¼	1½	1⅜	1⅝, 2⅛	1½	2	1⅝	2⅛, 2⅝	2	1½	2⅛	2⅝	2½		2⅝	3⅛	3		3⅛	3⅝	4		4⅛

(*) All Plug Kits and Bottom Assembly Kits for 3/4" Port Size Valves can be used in the 1" Port Size Valves for reducing capacity.

Item	Description		Qty.	Kit Number
1-2	Cap Seal Kit		1	202110
3-5	Packing Kit/Stem		1	202100
3-6, 12-15	Spring/Stem Kit	Rge. A/V	1	202006
		Rge. D	1	202007
1-6, 8 11-16	Bonnet/Spring Kit	Rge. A/V	1	202008
		Rge. D	1	202009
12-14, 16	Spring Kit, Bonnet	Rge. A/V	1	202481
		Rge. D	1	202482
16, 17, 19	Diaphragm Kit	Rge. A/V	1	200770
		Rge. D	1	200771*
* Rge. D Diaphragm Kit has two (2) Diaphragms				
16-19	Seat Kit, Pilot	Rge. A	1	202001
		Rge. V	1	202004
		Rge. D	1	202003
48	Body			Not avail. separately
49-50	Bolt/"O" Ring Kit	Bolts	4	201572
		"O"Ring	2	Only Avail. w/ Kit

Note: Pressure Pilot A2D2 used on main valve sizes 3/4" to 2" port.
Pressure Pilot A2D used on main valve sizes 2-1/2" to 4" port.

Repair Kits indicated for the A2D2 and A2D are common parts used on the integral pressure pilot mounted on the A4A Series Regulator.



A2D2, A2D MODULAR PRESSURE PILOT

A2D2 For A4—Port sizes 20—50mm (¾"—2")

A2D For A4—Port sizes 65—200mm (2½"—4")

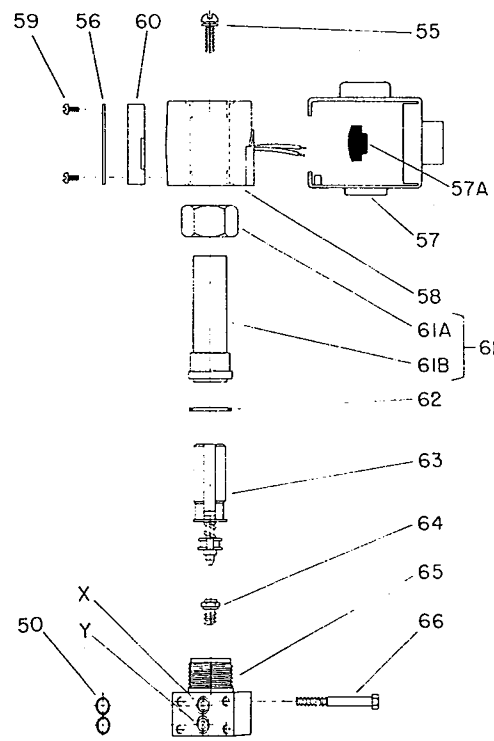
Fig. 11

Spare or Additional A2D2 and A2D Repair Kit Packages

Note: The following items are included in the above Kits in the exact numbers as required for field repair. If additional "O" Rings, Gaskets or Stem Packing are desired for spares or future use order from the following listing:

Item	Description	Qty.	Kit Package Number
2	Gasket Pkg./Seal Cap	12	202408
50	"O"Ring Pkg/Moduplate	12	202424
4	Stem Packing, Pkg.	25	202478

Item	Description	Qty.	Kit Number
55	Screw	1	Only Available with Kit
57	Housing, Coil	1	Only Available with Kit
57A	Bushing, Seal	1	Only Available with Kit
59	Screw	2	Only Available with Kit
60	Cover, Solenoid	1	Only Available with Kit
55, 57 57A 59, 60	Housing Kit	1	201629
58	Coil Assembly	1	See Part No. Page 8
61B	Tube Assembly, Solenoid	1	Only Available with Kit
61A	Nut, Solenoid Tube	1	Only Available with Kit
62	Gasket	1	Only Available with Kit
61A, 61B 62	Tube Kit, Solenoid	1	201036
50	"O"Ring	2	Only Available with Kit Also available in package. See below.
66	Bolts	4	Only Available with Kit
50, 66	Bolt/"O" Ring Kit	1	201574
62	Gasket	1	Only Available with Kit
63	Plunger/Needle Assembly	1	Only Available with Kit
62, 63	Plunger Kit, Needle	1	202019
62	Gasket	1	Only Available with Kit
63	Plunger/Needle Assembly	1	Only Available with Kit
62, 63	Plunger Kit, Needle (D.C only)	1	201021
62	Gasket	1	Only Available with Kit
63	Plunger/Needle Assembly	1	Only Available with Kit
64	Seat Assembly	1	Only Available with Kit
62, 63, 64	Plunger Seat Kit	1	201630
50	"O" Ring Pkg., Moduplate	12	202424
65	Body S6A	1	Not Available Separately



S6A MODULAR SOLENOID PILOT
For 4A—Port Sizes 20—100mm (¾"—4")
Fig. 12

VALVE SIZE		① FPT FLANGES		WELDING FLANGES								④ FLANGES				
		Nom. Pipe Size	Flange Pkg. No. (2/Pkg)	Nominal Pipe Size		Socket Weld Socket I.D.		Weld Neck Neck O.D.		Flange Package Number (2/Pkg)		Tubing O.D.		Fitting I.D.		Flge Pkg. No.(2/Pkg)
mm	Inches	Inches		Inches	② NW No.	Inches	mm	Inches	mm	Socket Weld	Weld Neck	Inches	③ mm	Inches	mm	
20	3/4	3/4	200016	3/4	20	1.070	27.81	1.050	26.67	200020	200023	1-1/8	28.57	1.130	28.70	200027
and	and	1	200017	1	25	1.365	34.67	1.315	33.40	200021	200024	1-3/8	34.92	1.380	33.05	200028
25	1	1-1/4	200018	1-1/4	32	1.705	43.31	1.660	42.16	200022	200025	1-5/8	41.27	1.631	41.43	200029
		1-1/4	200030	1-1/4	32	1.705	43.31	1.660	42.16	200032	200034	1-3/8	34.92	1.380	35.05	200036
32	1-1/4	1-1/2	200031	1-1/2	40	1.930	49.02	1.900	48.26	200033	200035	1-5/8	41.27	1.631	41.43	200037
												2-1/8	53.97	2.131	54.13	200038
40	1-5/8	1-1/2	200039	1-1/2	40	1.930	49.02	1.900	48.26	200041	200043	1-5/8	41.27	1.631	41.43	200045
and	and	2	200040	2	50	2,445	62.10	2.375	60.33	200042	200044	2-1/8	53.97	2.131	54.13	200046
50	2											2-5/8	66.67	2.631	66.8	200047
65	2-1/2	2-1/2	200048	2-1/2	65	2.945	—	2.875	73.03	200049	200050	2-5/8	66.67	2.631	66.83	200051
												3-1/8	79.37	3.131	79.53	200052
75	3	3	200053	3	80	3.575	90.81	3.500	88.90	200054	200055	3-1/8	79.37	3.131	79.53	200056
												3-5/8	92.07	3.631	92.23	200057
100	4	4	200062	4	100	4.575	116.20	4.500	114.30	200063	200064	4-1/8	104.77	4.132	104.95	200065

① FPT: Internal NPT (USA Standard Taper Pipe Thread).
② NW: Metric equivalent nominal size for steel tubing.
③ Metric copper tubing used for refrigeration.
④ ODS connections to fit copper tubing of given outside diameter. (Not for use with ammonia)

Definitions:
ODS - Outside Diameter Sweat
I.D. - Inside Diameter
O.D. - Outside Diameter
N.A. - Not Available

Flange Bolt Torque Requirements

Bolt Diameter	Valve Port Size	Torque
11mm (7/16")	13mm (1/2")	3.9 mkg (28 ft lb)
16mm (5/8")	20-50mm (3/4"-2")	11.8 mkg (85 ft lb)
19mm (3/4")	65-75mm (2-1/2"-3")	14.5 mkg (105 ft lb)
22mm (7/8")	100mm (4")	22.1 mkg (150 ft lb)

Safe Operation

(see also Bulletin RSB)

People doing any work on a refrigeration system must be qualified and completely familiar with the system and the Refrigerating Specialties Division valves involved, or all other precautions will be meaningless. This includes reading and understanding pertinent Refrigerating Specialties Division product Bulletins, and Safety Bulletin RSB prior to installation or servicing work.

Where cold refrigerant liquid lines are used, it is necessary that certain precautions be taken to avoid damage which could result from liquid expansion. Temperature increase in a piping section full of solid liquid will cause high pressure due to the expanding liquid which can possibly rupture a gasket, pipe or valve. All hand valves isolating such sections should be marked, warning against accidental closing, and must not be closed until the liquid is removed. Check valves must never be installed upstream of solenoid valves, or regulators with electric shut-off, nor should hand valves upstream of solenoid valves or downstream of check valves be closed until the liquid has been removed. It is advisable to properly install relief devices in any section where liquid expansion could take place.

Avoid all piping or control arrangements which might produce thermal or pressure shock.

For the protection of people and products, all refrigerant must be removed from the section to be worked on before a valve, strainer, or other device is opened or removed.

Flanges with ODS connections are not suitable for ammonia service.

Warranty

All Refrigerating Specialties Products are warranted against defect in workmanship and materials for a period of one year from date of shipment from factory. This warranty is in force only when products are properly installed, field assembled, maintained and operated in use and service as specifically stated in Refrigerating Specialties Catalogs or Bulletins for normal refrigeration applications, unless otherwise approved in writing by Refrigerating Specialties Division. Defective products, or parts thereof, returned to the factory with transportation charges prepaid and found to be defective by factory inspection will be replaced or repaired at Refrigerating Specialties' option, free of charge, F.O.B. factory. Warranty does not cover products which have been altered or repaired in the field; damaged in transit, or have suffered accidents, misuse, or abuse. Products disabled by dirt, or other foreign substances will not be considered defective.

THE EXPRESS WARRANTY SET FORTH ABOVE CONSTITUTES THE ONLY WARRANTY APPLICABLE TO REFRIGERATING SPECIALTIES PRODUCTS, AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, WRITTEN OR ORAL, INCLUDING ANY WARRANTY OR MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE. No employee, agent, dealer or other person is authorized to give any warranties on behalf of Refrigerating Specialties, nor to assume, for Refrigerating Specialties, any other liability in connection with any of its products.

COURSE OUTLINE - CRAY Y-MP Power And Refrigeration

1. Introduction and overview

2. Objectives

3. Classroom portion
    A. Big picture general system description and block diagram
    B. Refrigeration theory and maintenance
        1. RCU 1
        2. HEU
        3. RCU 2
    C. Power theory and maintenance

4. Summary of class portion

OBJECTIVES - CRAY Y-MP Power And Cooling

Upon completion of this section, the student will be able to:

- Work safely and practice predictive maintenance
- Understand the concepts of power and cooling
- Give definitions for a list of basic power and refrigeration terms
- Describe what each item does if given a list of equipment and parts related to power and refrigeration
- Know what tools and documentation are available, and how and when to use them
- Perform routine maintenance and adjustments on the system and demonstrate selected procedures
- Monitor the system and tell if there is a problem. Be able to correctly fill out the weekly refrigeration check off sheet
- If you can't fix a problem, know who to call, and be able to hold an intelligent conversation

CRAY Y-MP GENERAL SYSTEM DESCRIPTION AND BLOCK DIAGRAM

1. Safety
2. Configuration varieties
3. Configuration requirements and block diagrams
4. Facts and figures

RECOMMENDED REFRIGERATION TOOLS

DESCRIPTION	PART NUMBER	ON SITE	ON ORDER
Charger, refrigeration	01015400	________	________
Leak detector, refrigeration	01015100	________	________
Oil, refrigeration 150 viscosity (1 gallon)	01023900	________	________
Pump, charging refrigeration oil	01015900	________	________
Pump, 120 V 60HZ vacuum	01505200	________	________
Test kit, acid	01564300	________	________
Tweezers, micro assembly curved	01531700	________	________
Volt-amp meter, clamp on	01140200	________	________
Wrench, ratchet refrigeration	01532200	________	________
Wrench, flare nut 12 pt. 3/4 x 1	01542203	________	________
Wrench, flare nut 12 pt. 15/16 x 1 1/8	01542204	________	________
Wrench, refrigeration 8M	02009300	________	________
Wrench, refrigeration 8F	02009301	________	________
Wrench, refrigeration 12	02009302	________	________
Wrench, refrigeration 16M	02009303	________	________
Wrench, refrigeration 16F	02009304	________	________
Wrench, crowsfoot 1 1/4 inch 3/8 inch drive		________	________
Caliper, dial 6 inch	01527900	________	________
Manifold set		________	________
Volt, ohm meter, fluke	01221200	________	________
Temperature probe, fluke	01140500	________	________
Quick couplers 16C, 17C		________	________

CRAY Y-MP COOLING

Heat Load

The heat generated by the chips is conducted away from the die through the bottom of the chip case directly to the bottom plate. To ensure good thermal conductivity, a thin layer of conductive grease is applied between the chip and the bumps on the module plate. The power for each logic chip averages 7.5 watts for 4.5 volts and 1.5 watts for 2 volts for a total of 9 watts per chip. With 78 chips per board, this amounts to 2,808 watts per CPU module. The memory boards have 39 logic chips and 288 memory chips. Since the average power per memory chip is 1.25 watts, the heat generated by the memory module is 2,844 watts. The heat generated by the power supplies (the inefficiency of the supply), the heat generated by the buck transformers, and the loss in the diodes (a voltage drop of .7 volts times the 2,200 amps) amounts to a total of 45,000 watts. There are eight modules per eight CPUs in the CRAY Y-MP for a total of 22,464 watts. Also, there are 32 modules per memory for a total of 91,008 watts, plus the power supply consumption total of 158,472 watts per CRAY Y-MP.

By testing, it has been determined that a temperature rise of the coolant of 10 degrees Fahrenheit from 65 degrees to 75 degrees will satisfactorily cool the chips and keep the chip die temperature well below the 85 degrees ~~Celsius~~ set limit. The amount of coolant required to maintain the 10 degree temperature rise is two gallons per minute (GPM) per module. The temperature rise through the power supply plate can be higher than the module plate, approximately 15 - 20 degrees Fahrenheit. The required flow for the entire plate is ~~60~~ 45 GPM.

A total flow of 205 GPM is being circulated through the system by a pump in the chiller unit. From the pump, the coolant flows through the chiller barrel, where it will be cooled down to 65 degrees Fahrenheit, plus or minus 3 degrees. It is important that the temperature does not go below the 65 degree mark to prevent any condensation in the mainframe. After the chiller barrel, the flow is divided into three circuits. One circuit, with a flow rate of 160 GPM, will provide cooling of the modules. The coolant flows into a 67-inch tall manifold which evenly distributes the flow to the 80 module plates. From the manifold it flows through a quick disconnect no-leak coupling through a hose to the plate, through the plate and out through an outlet hose, then a coupling and into the outlet manifold. The other circuit, with a flow rate of 45 GPM, will provide cooling for the power supply and plate. Just before this circuit enters the plate, it is split in two for the two plate inlets. Ball valves are added before the two inlets to the plate so that the flow can be regulated to achieve an even temperature rise through the two plate passes. From the power supply plate outlet and the outlet manifold, the coolant will flow back to the inlet of the pump to complete the circuit.

The chiller is a refrigeration system with a compressor, condenser, and an evaporator. The chiller barrel is the evaporator, where refrigerant (R22) goes from a low pressure liquid to a low pressure gas, and takes the heat from the coolant. It then flows to the compressor, where it is compressed into a high pressure, high temperature gas, and then goes to the condensing unit where freon (R22) is condensed to a high pressure liquid. In this process, it gives up heat to the condenser cooling water.

POWER CONSUMPTION

CPU Module = 2808 watts

Logic chip = 7.5 watts for 4.5 volts
+ 1.5 watts for 2.0 volts
9.0 watts per logic chip
x 312.0 watts per module (78 x 4)
CPU power = 2808 watts per CPU
x 8 8 CPUs
22,464 watts

Memory Module = 2844 watts

Logic chip = 9.0 watts per logic chip
x 156.0 logic chips per module
1404 watts

Memory chip = 1.25 watts per memory chip
x 1152 watts per module (288 x 4)
1440 watts per module

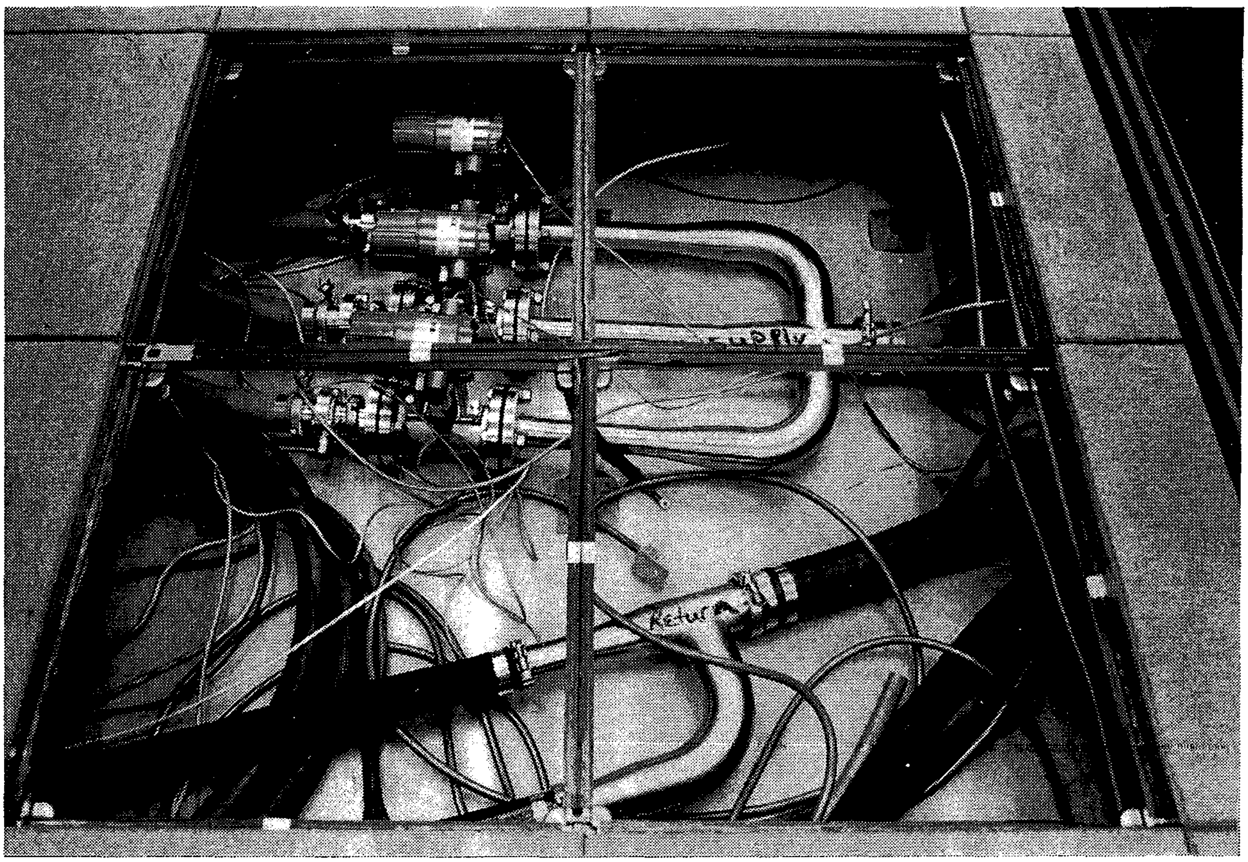
1440 watts logic
+ 1404 watts memory
2844 watts per memory module
x 32 modules per memory
Memory power 91,008 watts

Power Supplies = 45,000 watts

Heat from power supplies (inefficiency)
Buck transformers
= Loss in diodes (.7 volts x 220 amps)

Total Watts: 22,464 = CPU watts per 8 CPUs
91,008 = Memory watts per 32 modules
+ 45,000 = Power supplies
158,472 watts

Supply lines = Black
Return lines = Red



Module Chassis

The module chassis is designed as an open frame consisting of vertical bars, the length of which is the height of the chassis (67 inches).

There are three types of bars:

1. The heavy corner piece that is 1/2 x 6 inches cross-section and which gives the chassis the mechanical strength.

2. The wire routing bar with the same cross-section. They are very similar and have the same function as on the CRAY X-MP mainframe to support the wiremat.

3. The thin bars with cross-section of .2 x 1 inch that are located between the corner pieces and the routing bars.

All the bars are mounted to six spacer plates that tie all the parts together to form a structural chassis. There are 13 bars on each side of the spacer plates: two corner bars, two wire routing bars, and nine thin bars. Each bar has 84 slots for the 80 module plates and four extra. The wired connectors are mounted between the bars, so it is very important to hold the distance between the bars to a very tight tolerance.

The spacer plates are made of two pieces, which make it possible to build the chassis in two pieces for ease of assembly and wiring. Both halves can be wired at the same time, thus cutting the wiring time in half.

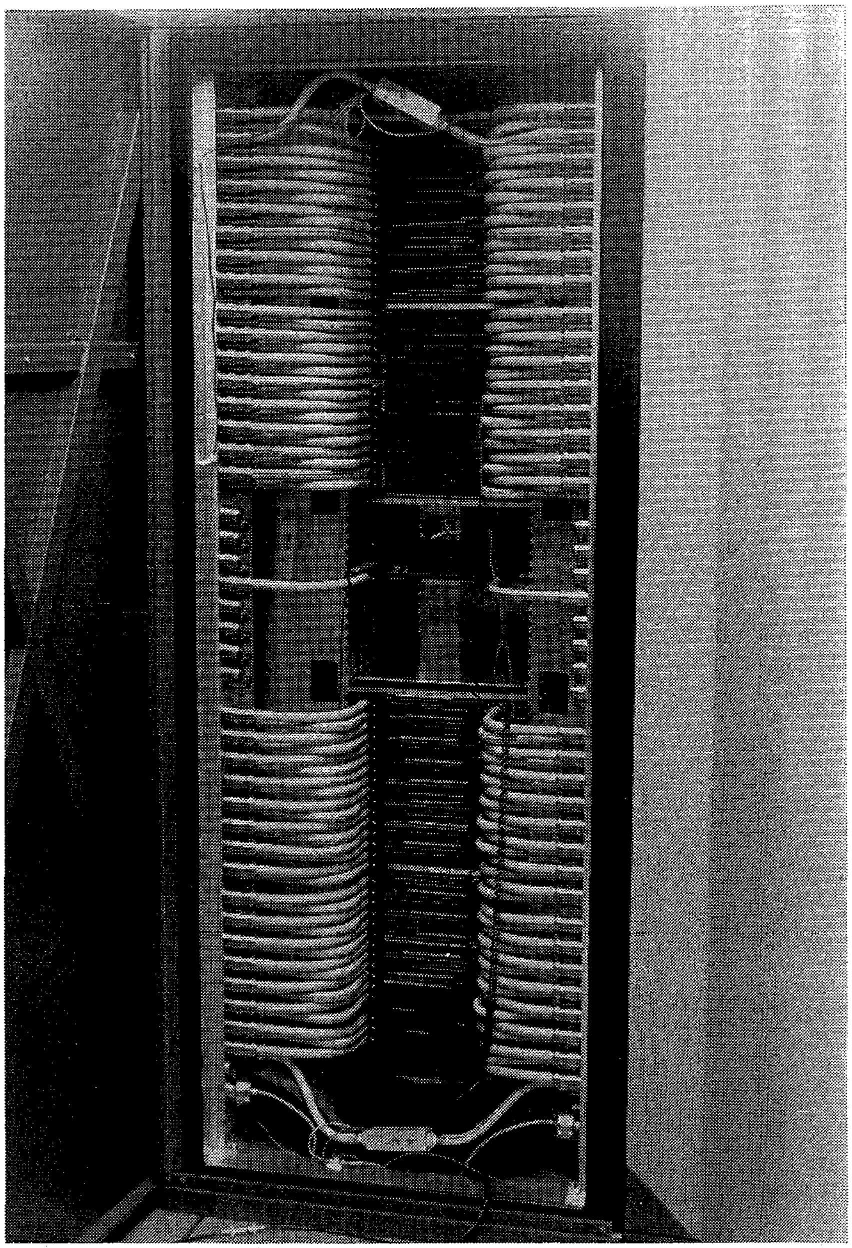
The six spacer plates divide the chassis into five sections, with each section holding eight modules. The two top sections hold half of the memory, namely 16 modules. The middle section is for the entire CPU section, eight CPU modules, and the remaining 16 memory modules in the two lower sections. Above and below the CPU section are spaces for wires to cross from one side of the chassis to the other side. This was done for the VHISP channel wires that come from the side of the chassis opposite to where the SSD is located.

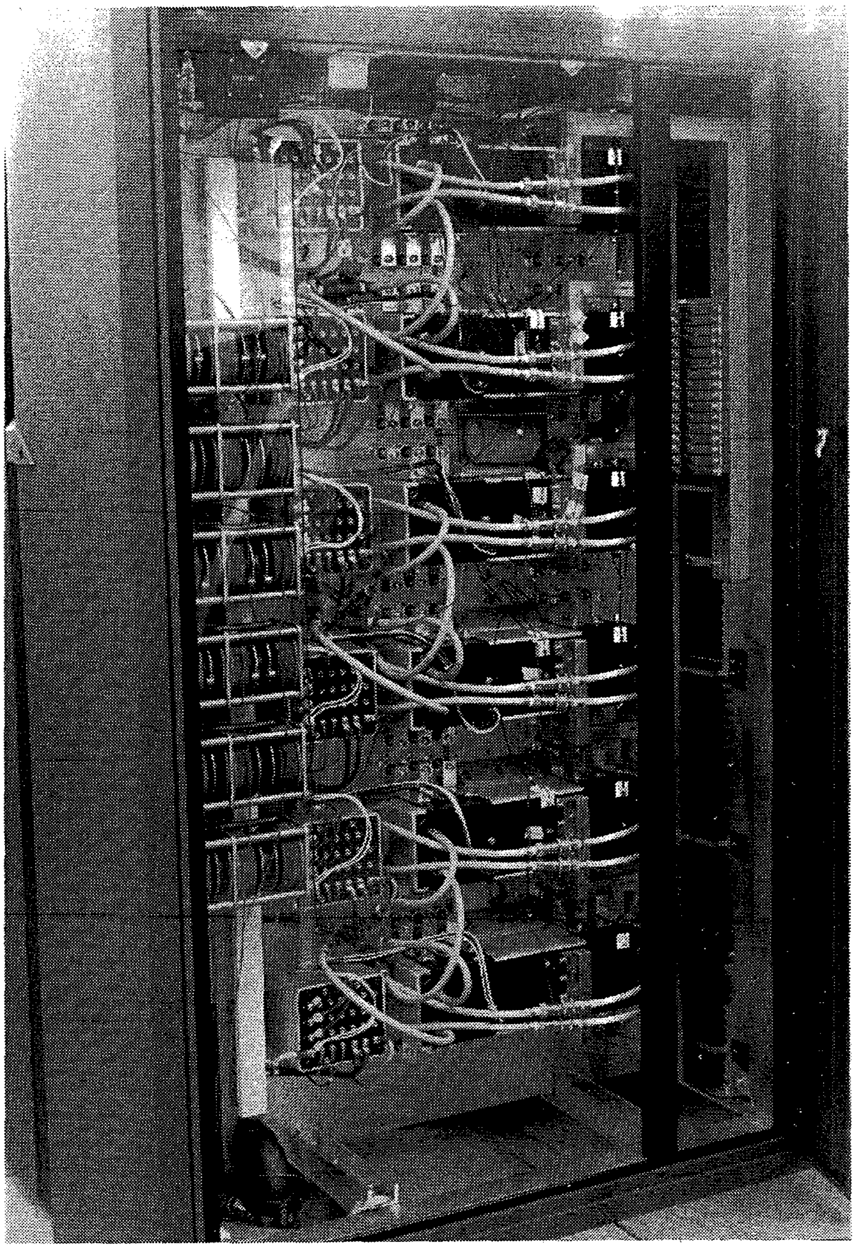
The material for the chassis is hot rolled steel because of its strength, easy machinability, and ability to maintain the required straightness and flatness.

Power Supply Plate

Behind the module chassis and tied to the spacer plates is the power supply plate. The plate is formed like a "T", with the top of the T being seven inches long. This part is tied to the chassis. Special shouler screws are used to ensure tight vertical alignment tolerance. This is important because this part of the plate is also used as the ground connection for the module plates.

The module plates are tied to the power supply plate, with four captive screws for each plate. The other part of the power supply plate is two inches thick and 67 inches high by 34 inches long. This is where the 12 power supplies and the 12 buck transformers are mounted. There are





six 4.5 volt power supplies mounted on one side, and four 5.2 volt supplies and two 2 volt supplies mounted on the other side.

Because the power supplies are mounted so close to the modules, the voltage drop in the power busses and in the ground return will be held to a minimum. Each power supply will have a heavy power bus (1 x 1 inch copper) that will run towards the modules, and will also have a vertical section 1/2 x 4 inches brazed to it. From here, there are short "L" shaped bus straps going directly to the modules.

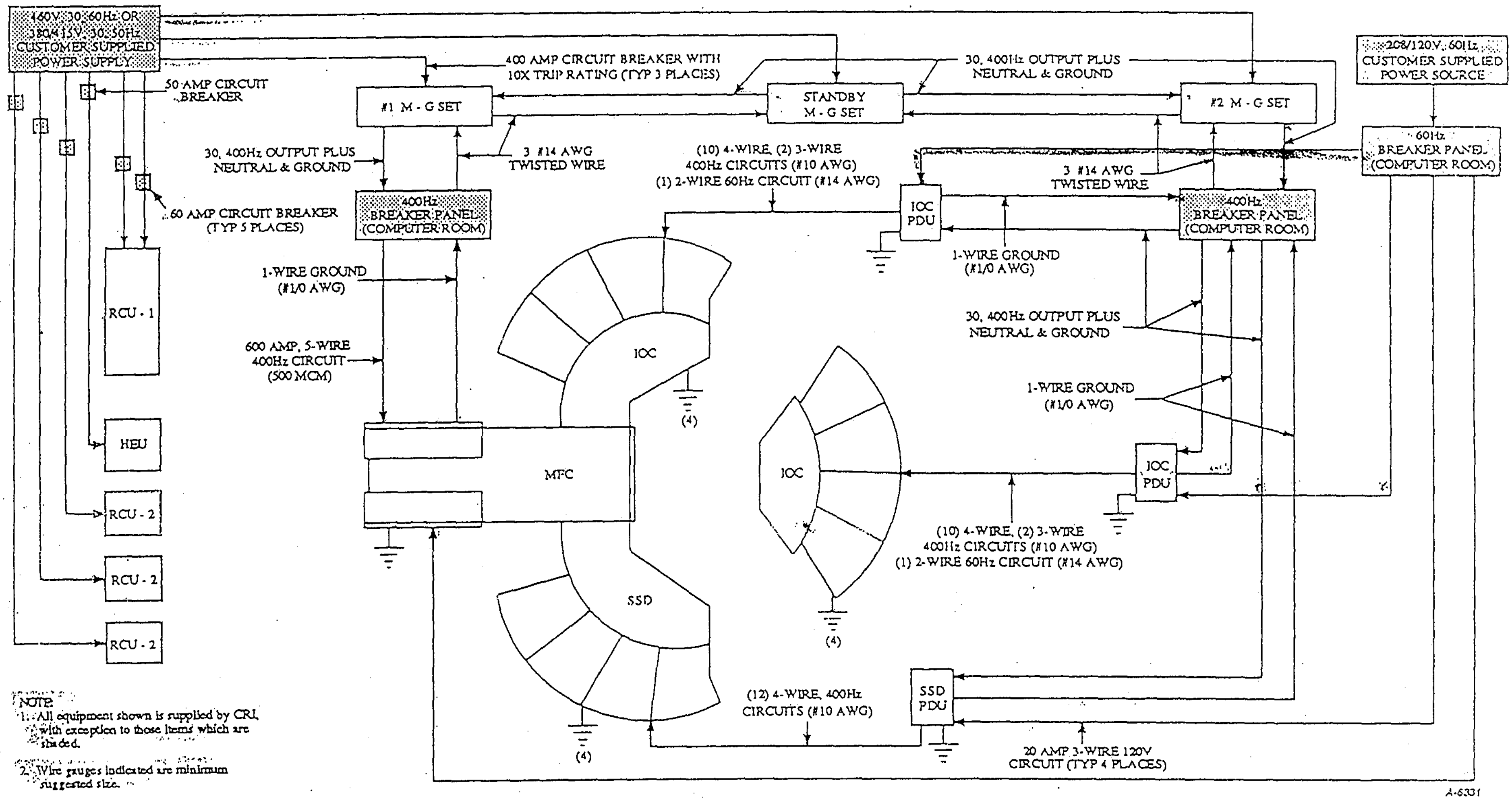
The 4.5 volt and 5.2 volt power supplies are capable of 2,200 amps of output, and the 2 volt power supply is capable of 2,800 amps, which is only slightly more than the expected requirement. These power supplies are designed by Schott Corporation in Minneapolis, Minnesota; the same manufacturer as the current CRAY X-MP power supplies.

Besides being the mounting plate for the power supplies and the buck transformers, the power supply plate is carrying the cooling media (fluorinert FX74) for cooling the power supplies, the diodes, and the buck transformers. The plate has two sets of cooling passes. One set has passes through the plate to conduct the heat away from the power supply cases, the diodes, and the buck transformers. The other set provides coolant for the internal serpentine tube that runs through the power supplies. The coolant comes out of the plate, through a hose to the power supply connection, through the internal tube to the output connection, and then back to the plate through a hose. The internal pass will cool approximately 1/2 of the heat generated by the power supply.

Power Distribution

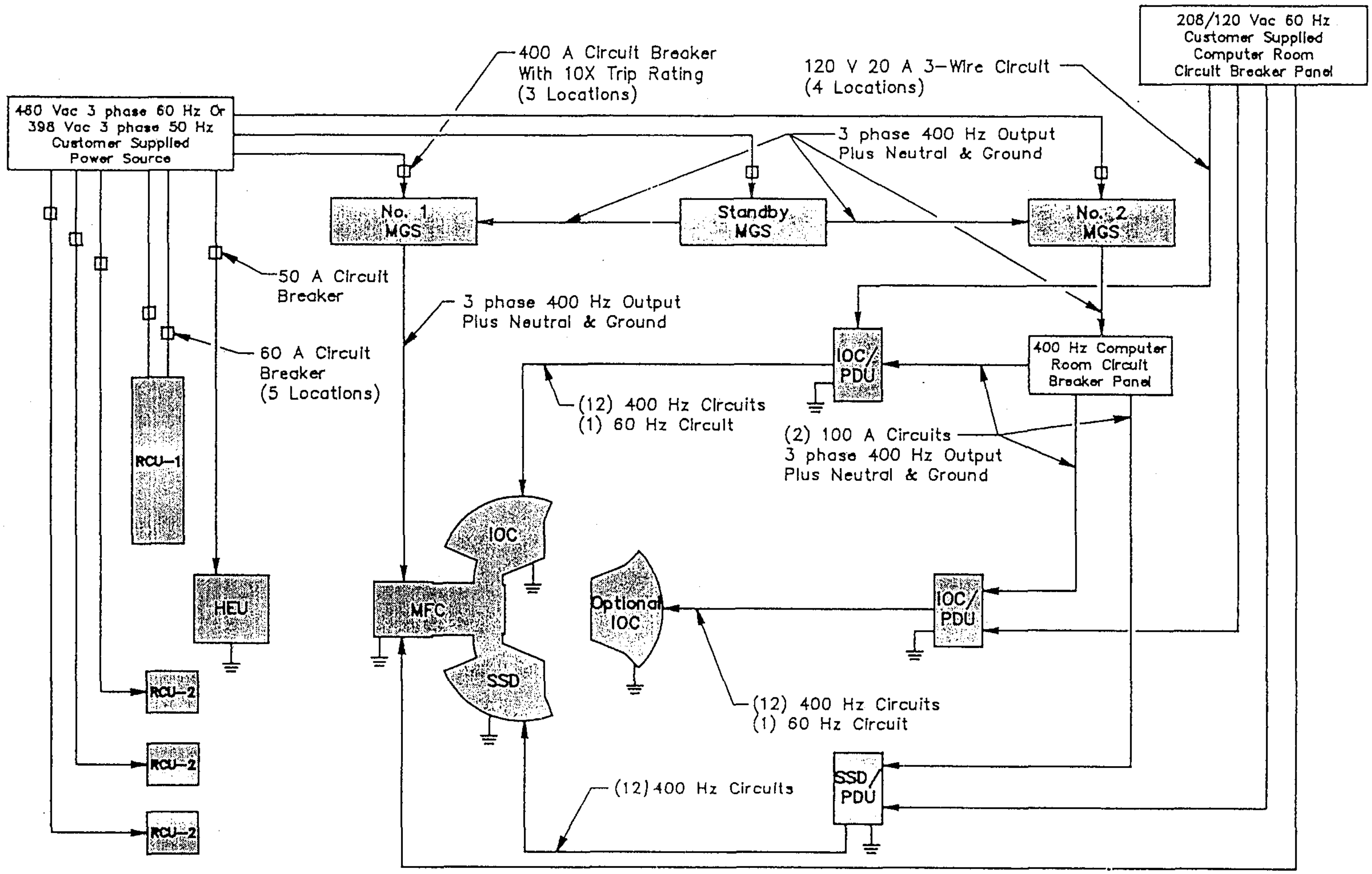
All the power required for the mainframe, approximately 160KVA, is produced by the motor generator (MG). The power cables for the mainframe come up through the floor on both sides of the power supply plate, where they are tied into a series of terminal blocks.

From the terminal blocks the wires are routed up along the power supply plate and branch off to the power terminals on the buck transformers. A set of terminals are connected to the variac and the power supply is connected to one of six sets of output terminals. The set selected depends on the load on the power supply so that the variac can adjust the voltage within the required range. The DC power distribution from the power supply output bus is described in the power supply plate section.



NOTE:
1. All equipment shown is supplied by CRI, with exception to those items which are shaded.
2. Wire gauges indicated are minimum suggested size.

CRAY Y-MP POWER LINES WIRE DIAGRAM
(SHEET 1 OF 2)

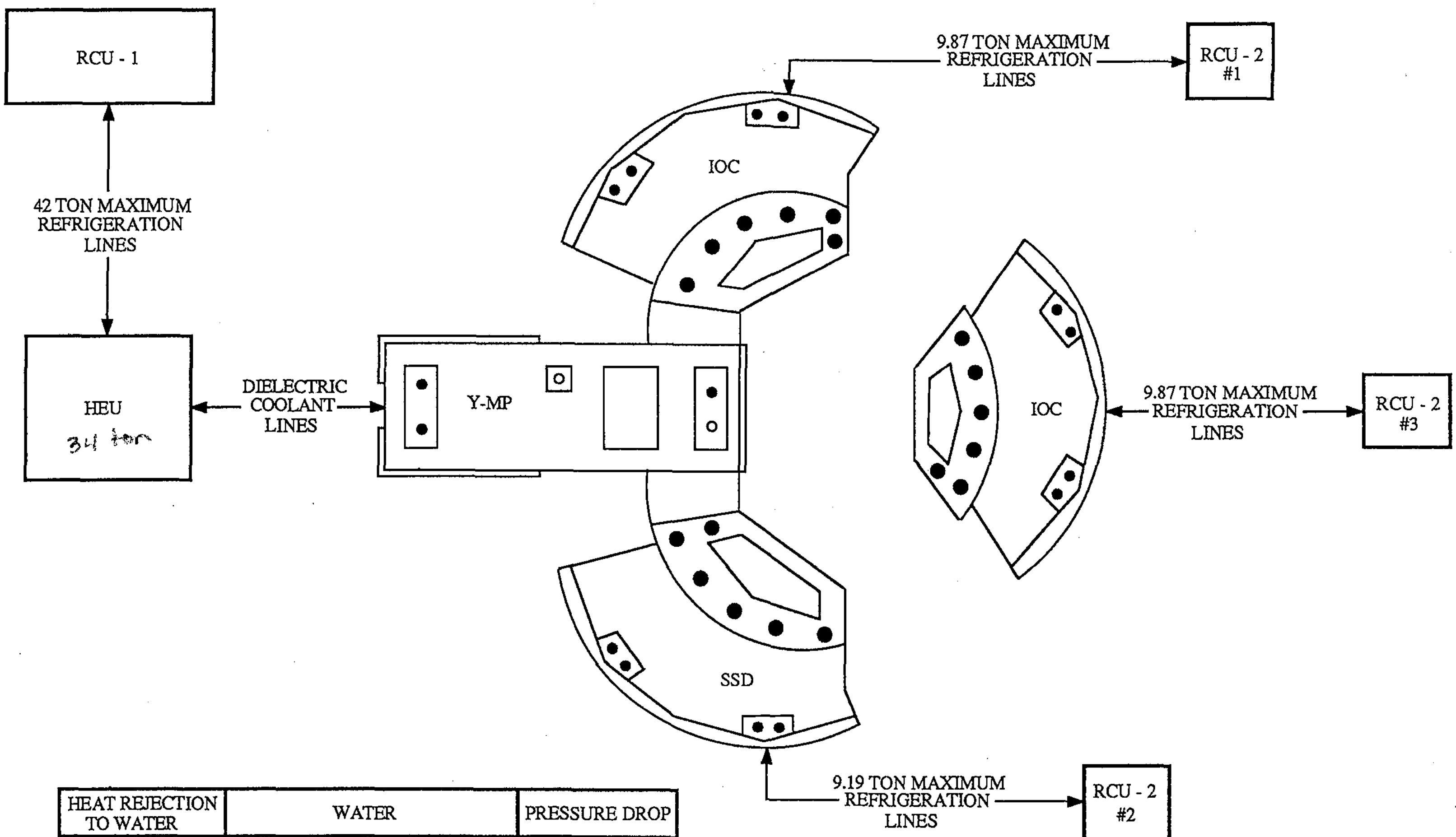


Note:
1 Shaded Equipment is Supplied By CRI.
Customer Supplies All Remaining Devices and Materials.

A-6959

BASIC CONTROL WIRING FOR A CRAY Y-MP SERIES COMPUTER SYSTEM

CRAY PROPRIETARY

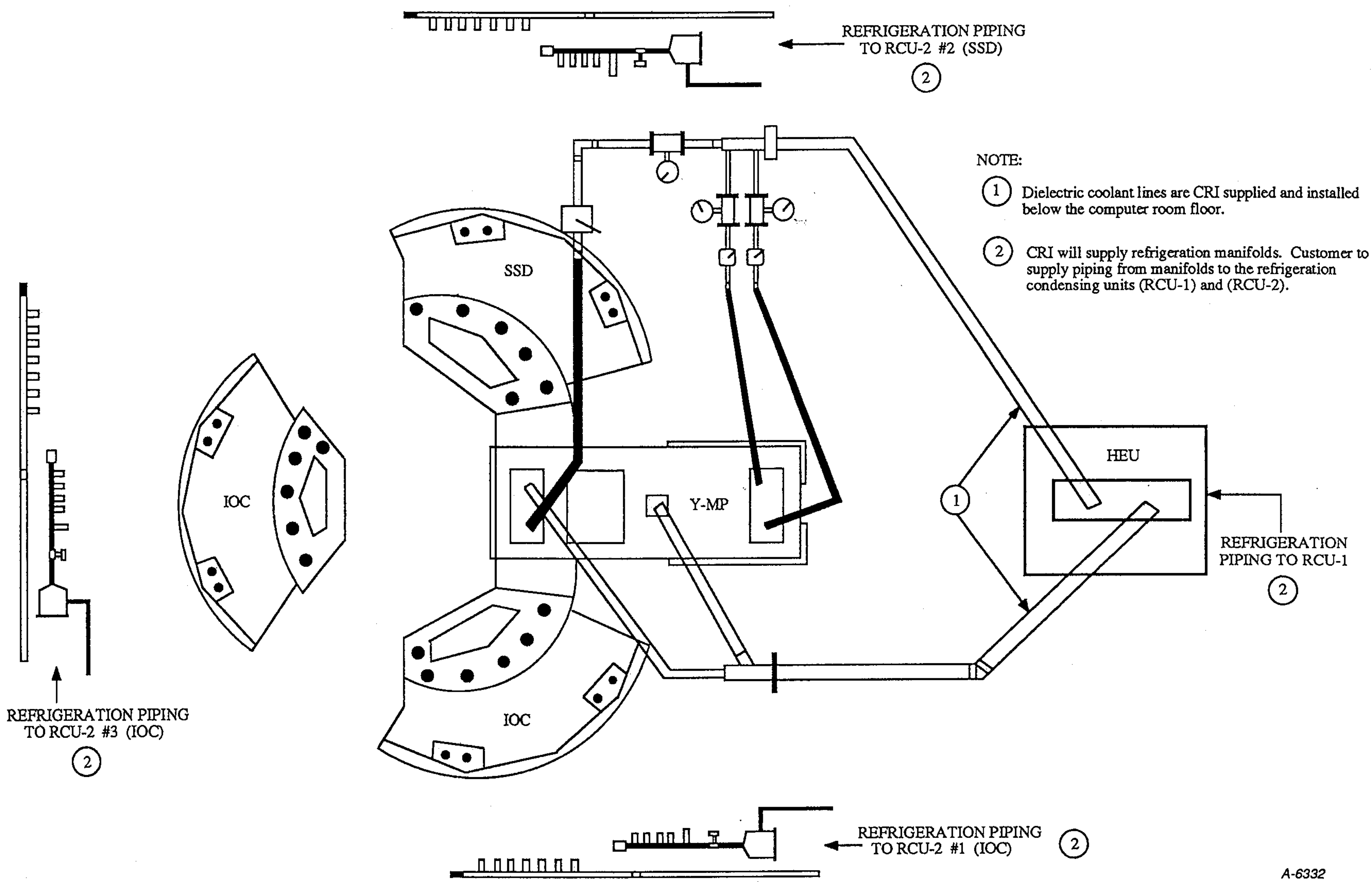


	HEAT REJECTION TO WATER	WATER			PRESSURE DROP	
	KBTU/HOUR	GPM	H^3/HOUR	TEMPERATURE	PSI	KPA
RCU - 1 (MFC)	571	38	8.63	60° INLET 90° OUTLET	10	69
RCU - 2 (IOC) (EACH)	153	11	2.52	60° INLET 90° OUTLET	10	69
RCU - 2 (SSD)	145	10	2.16	60° INLET 90° OUTLET	10	69

$$\frac{\text{system BTU's}}{500.5 \times \text{In/Out temp diff.}}$$

A-6328

CRAY Y-MP COOLING



CRAY Y-MP COOLING DIAGRAM

REFRIGERATION THEORY AND MAINTENANCE

I. Refrigeration overview

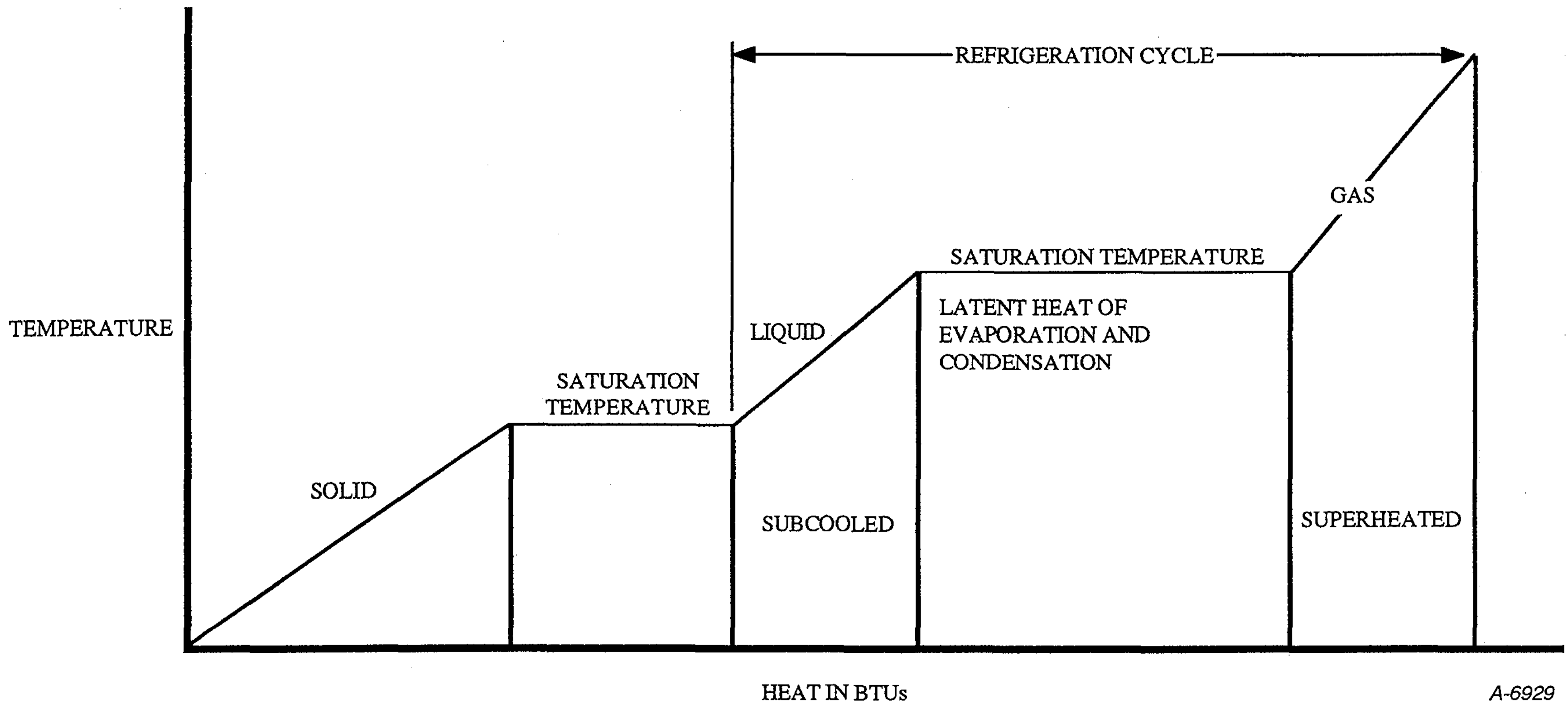
A. Types of heat transfer
B. Saturation temperatures and pressures, subcooling, superheating
C. Temperature, pressure, and volume relationships
D. Temperature, pressure chart, freon characteristics
E. Refrigeration system components and operation

II. Cray refrigeration system

A. Fifty ton condensing unit analysis
B. Filters
C. Evaporator
D. Expansion valves
E. EPR valve
F. Fifteen ton condensing unit differences
G. Refrigerant piping and fittings
H. HEU analysis and components

III. Maintenance and troubleshooting

A. Monitoring the system
   1. Weekly check-off sheets
   2. Freon checking and adding
   3. Oil checking and adding
B. Adjustments and troubleshooting
   1. Refrigeration maintenance video
   2. Filter replacement
   3. Expansion valve replacement video


REFRIGERATION CYCLE
GAS
SATURATION TEMPERATURE
LATENT HEAT OF
EVAPORATION AND
CONDENSATION
TEMPERATURE
LIQUID
SATURATION
TEMPERATURE
SOLID
SUBCOOLED
SUPERHEATED
HEAT IN BTUs
A-6929

FREON CHARACTERISTICS

R22 refrigerant freon is used in the system. R22 only!

- Clear
- Colorless
- Liquid/gas depends on temperature/pressure
- Non-toxic
- Non-irritant
- Non-explosive
- Non-flammable
- Lungs - refrigerant disease

FLUORINERT FX74 CHARACTERISTICS

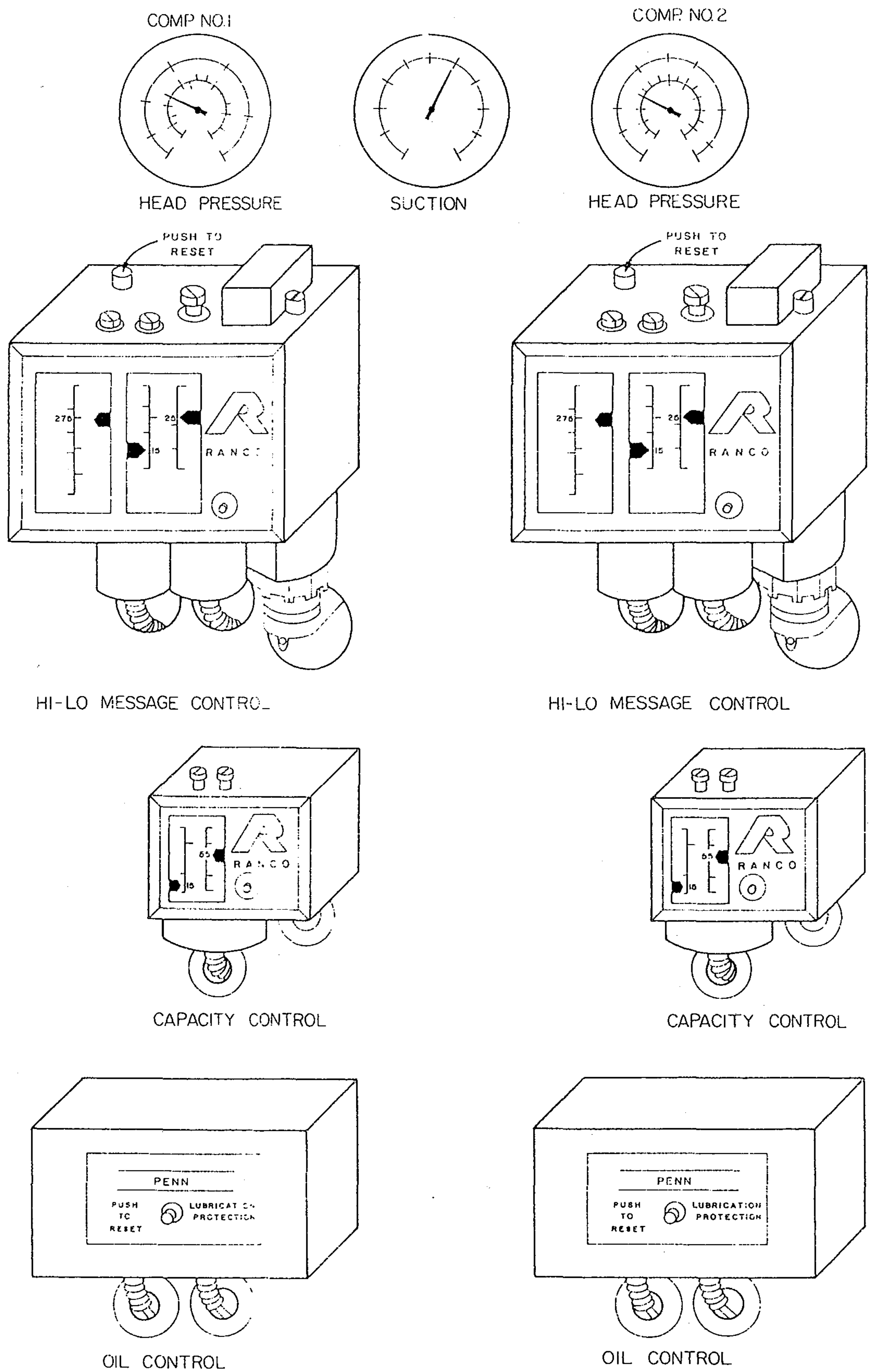
- Safe to handle
- Clear
- Colorless
- Odorless
- Tasteless
- Non-toxic
- Non-flammable

Typical Properties

- Boiling point 56 degrees Fahrenheit
- Pour point 110 degrees Fahrenheit
- Density is equal to 15 pounds gallon

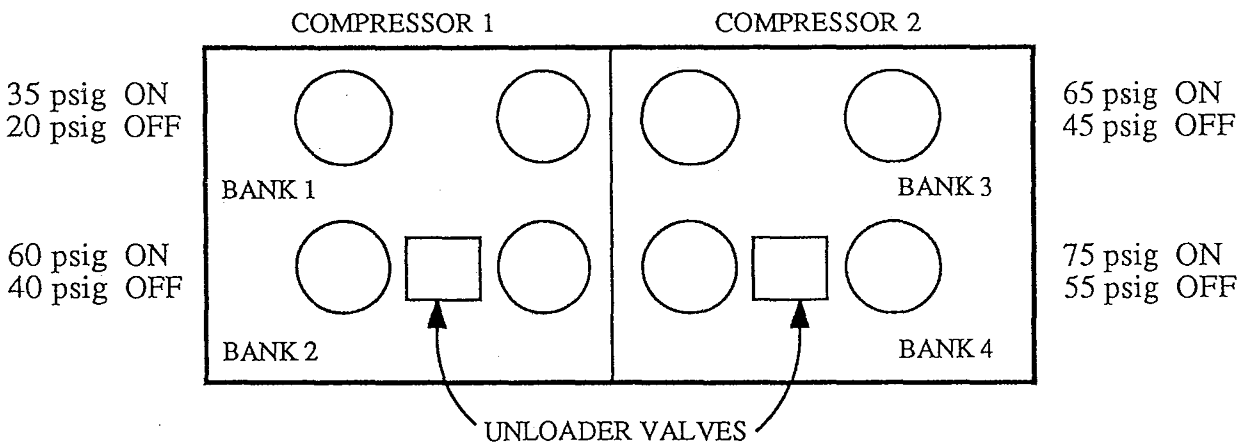
Vapor Characteristics

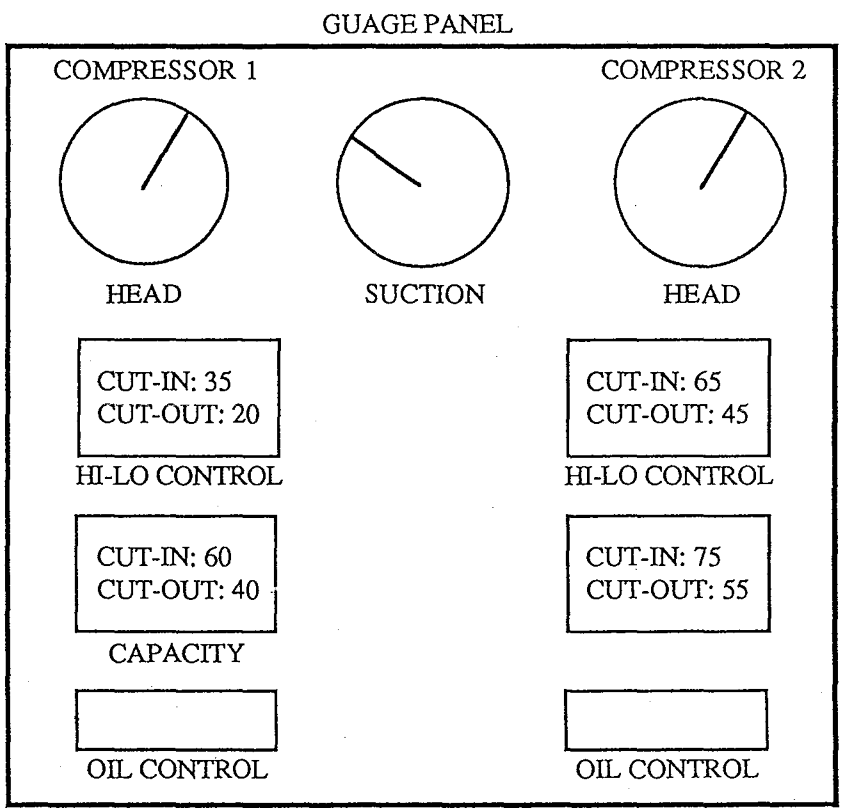
- Vapors are 15 - 20 times heavier than air
- In absence of ventilation tends to settle in low areas
- Can cause oxygen deficiencies causing headaches and dizziness


COMP NO.1
COMP NO.2
HEAD PRESSURE
SUCTION
HEAD PRESSURE
PUSH TO RESET
PUSH TO RESET
RANCO
RANCO
HI-LO MESSAGE CONTROL
HI-LO MESSAGE CONTROL
RANCO
RANCO
CAPACITY CONTROL
CAPACITY CONTROL
PENN
PUSH TO RESET
LUBRICATION PROTECTION
PENN
PUSH TO RESET
LUBRICATION PROTECTION
OIL CONTROL
OIL CONTROL

B-2019

50 ton RCU bank sequencing Example 1
Sequence 1-2-3-4





A-6931

1 - OVERVIEW OF POWER DISTRIBUTION AND REFRIGERATION

The CRAY Y-MP computer system power distribution and refrigeration systems are manufactured to assure optimum performance of the mainframe computer. A microprocessor-based control system enables power sequencing, environmental protection, and uniform cooling.

Power distribution and refrigeration in the CRAY Y-MP computer system is provided by five major components: the control system that monitors operation of the mainframe and other computer system components; the Motor Generator set (MGS) that provides 400 Hz power to the mainframe; linear power supplies that provide operating voltage to the modules in the mainframe; and the Heat Exchange Unit (HEU) and Refrigeration Condensing Units (RCUs) that provide cooling to the computer system.

REFRIGERATION

Figure 1-1 is a block diagram of the CRAY Y-MP refrigeration system. The refrigeration system contains an RCU and an HEU. The refrigeration system is Freon-based and cools a dielectric fluid such as Fluorinert in a Freon-to-dielectric fluid heat exchanger. The HEU controls temperature stability and contains a pump that circulates dielectric fluid.

The mainframe is cooled by chilled dielectric fluid circulating through each module, power supply, and power supply mounting plate. Each dielectric fluid circulation loop has an adjustable ball valve to control the flow rate. The temperature of the heat load is raised by decreasing the dielectric fluid flow rate, and lowered by increasing the flowrate. There is an optimum temperature and flow rate for each circulation loop. [Details of the optimum temperatures and flow rates are described in Section 4, under "HEAT EXCHANGE UNIT (HEU)".]

Connections between the dielectric fluid main manifold piping and mainframe hoses are made with quick-disconnect couplings. The couplings have a ball valve built inside them. Before the couplings are disconnected to replace modules or perform other maintenance, both valves are shut off. Connections to power supplies and modules are made with self-sealing, quick-disconnect couplings. The dielectric fluid is sealed off both sides of the coupling when the coupling is opened.

POWER DISTRIBUTION

The power distribution system in the CRAY Y-MP computer system has 400-Hz, 208 V supplied by the MGS. Three MGS's are required at each computer site: an MGS to

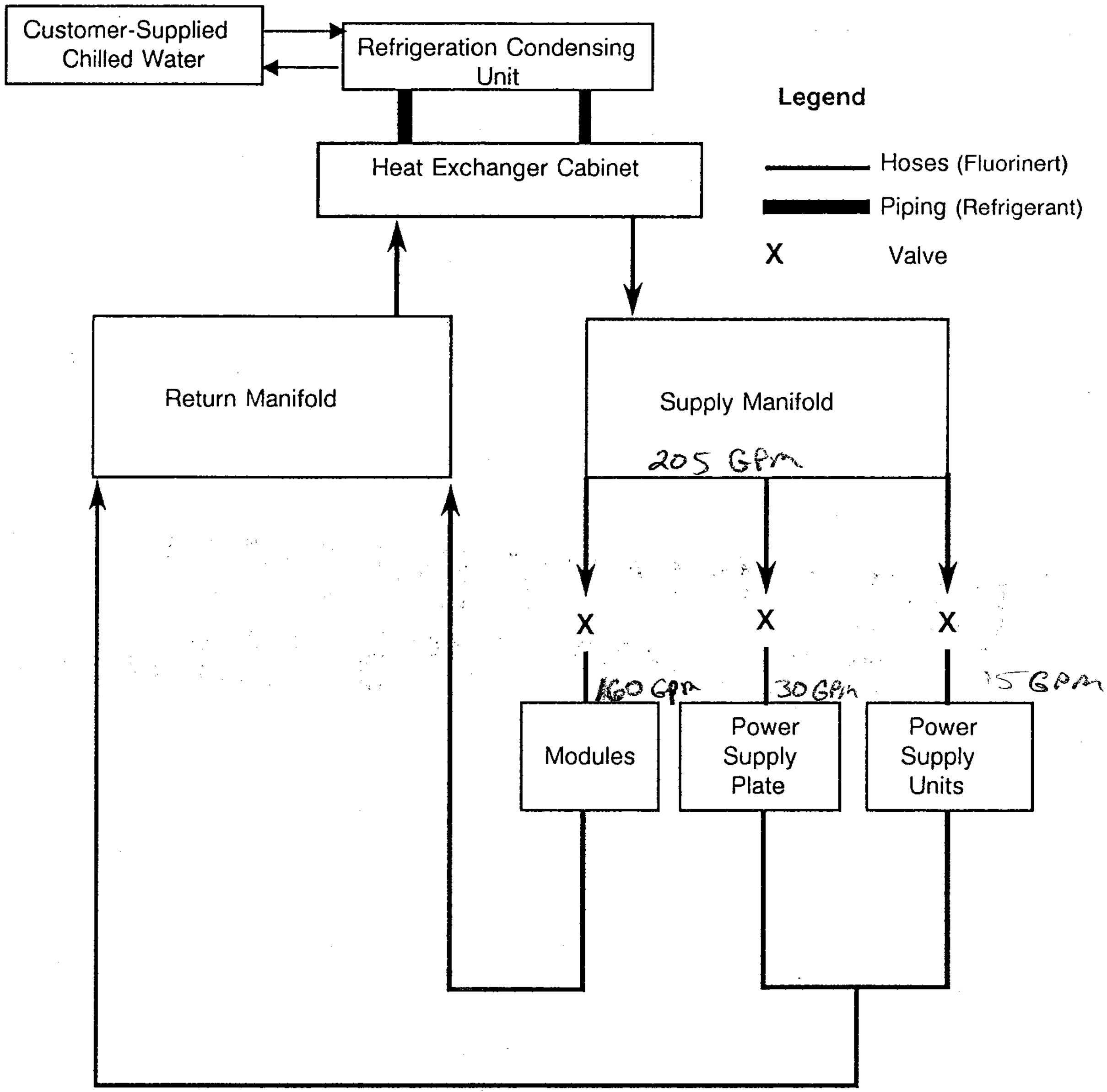


Figure 1-1. CRAY Y-MP Refrigeration Block Diagram

supply power to the mainframe, a standby MGS, and an MGS to supply power to the IOS's and SSD.

Figure 1-2, the CRAY Y-MP Power Distribution Block Diagram, shows how 400-Hz power is sent from the MGS to a main circuit breaker panel at the voltage adjust panel of the mainframe. From the mainframe breaker panel, the 400-Hz power is sent to the variable transformers and buck transformers in the mainframe for adjustment purposes. The buck transformers provide course adjustments to the input power of the mainframe

WARNING

Toxic vapor hazard. Do not inhale or ingest decomposed Fluorinert. Decomposed Fluorinert produces a pungent odor with vapors heavier than air and tends to sink to the floor until it is removed or evaporated. Fluorinert starts to decompose at its boiling point 207 °F (97 °C) or if subjected to electrical arcing, open flame, glowing electronic heating elements, soldering guns, or ignited tobacco. Toxic vapors produced by decomposed Fluorinert are perfluoroisobutylene (PFIB) and hydrogenfluoride (HF).

If these toxic vapors are inhaled or ingested remove person to fresh air and call a physician immediately. Symptoms are dizziness, nausea, and impaired coordination.

You must read Safe Use and Handling of Fluorinert, publication number HR-0306, when using equipment that contains Fluorinert.

power supplies and the variable transformers provide a fine adjustment with an adjustment knob on the voltage adjust panel. The output of the -4.5 Vdc, -5.2 Vdc, and -2.0 Vdc power supplies is bused to modules in the mainframe chassis.

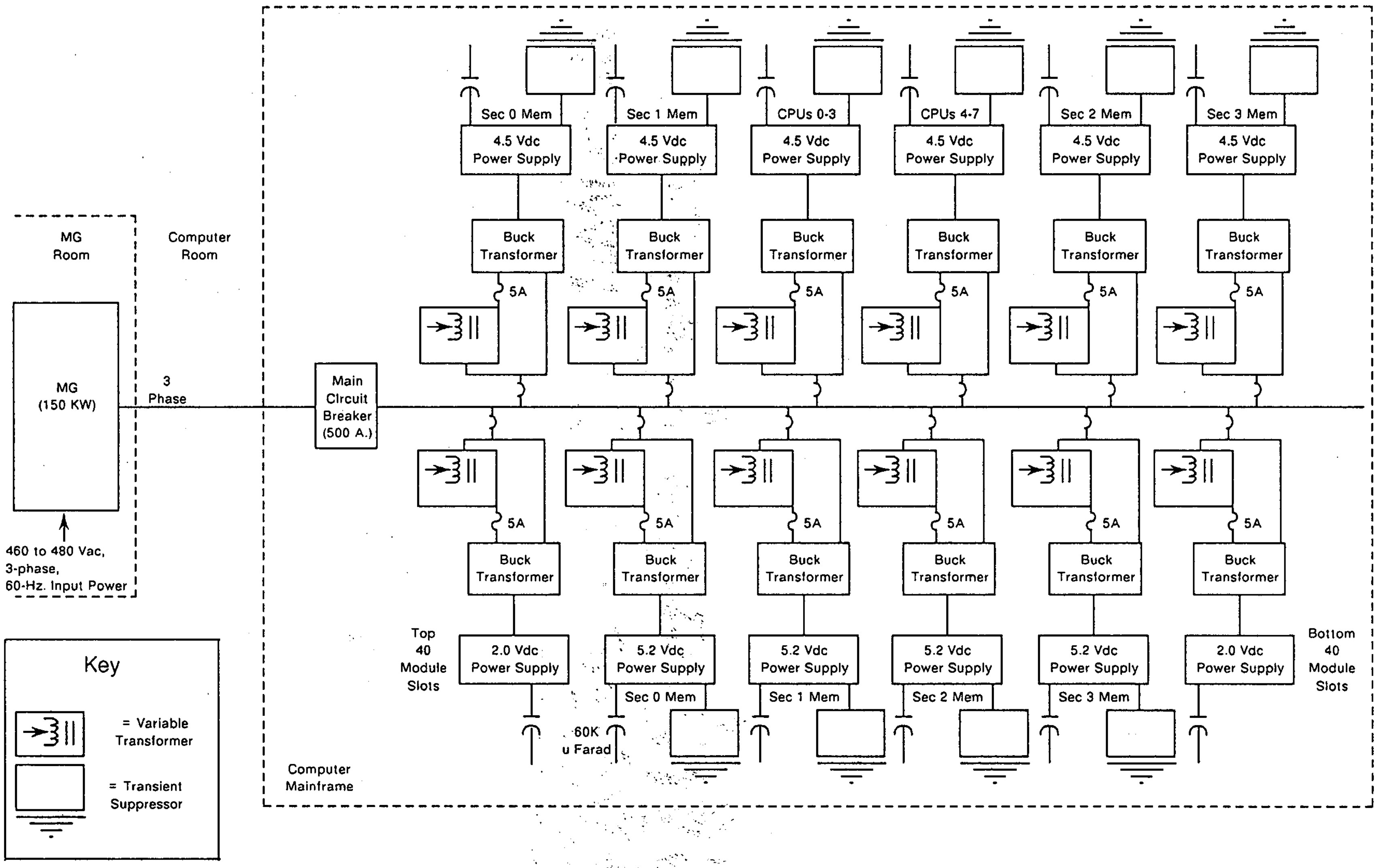


Figure 1-2. CRAY Y-MP 400 Hz Power Distribution

2- CONTROL SYSTEM

This section describes the control system that monitors refrigeration and power distribution for the CRAY Y-MP computer system. The control system is microprocessor-based and consists of three modules mounted on the mainframe above the voltage adjust and circuit breaker panel.

The control system operates with two scanners (A and B) and a main processor that interfaces each of the scanners for overall control. Each scanner monitors the same set of primary and backup sensors. The scanner microprocessor reads information the sensor sends and determines whether normal operating limits are maintained or exceeded. The status of all scanner information is shown on an LED panel located on the control system Display module.

This section provides the following information:

- Control system monitoring features including a description of how an operation of the computer system is monitored

- Manual operation of the control system console

- Control system theory of operation

- A description of the warning and power-down sequence caused by system faults

MONITORING FEATURES

Control system monitoring during computer system operation is enabled by a possible 192 primary channel sensors and 192 backup channel sensors that are read by the scanner microprocessor. Sensors in the CRAY Y-MP computer system are divided into the following seven categories. (Refer to Figure 2-1, CRAY Y-MP Control System Console, for the labels on the control system console: Module Temp., Voltage, Pressure, Temperature, MG, and Self Test.):

- Module Temperature
- Power Supply Voltage
- Pressure
- Transformer, Power Supply Plate, and Inlet/Outlet Manifold Temperatures
- MG Voltage
- Systems Monitoring
- Self Test

The following information in the subsection describes the actual monitoring levels, where monitoring takes place, and other monitoring information during computer system operation. Table 2-1, Control System Monitoring (On Limits), provides a quick reference for monitoring information during computer system operation. Table 2-2, Control System Monitoring (Off Limits), contains monitoring information for when the computer system has been powered down. The text in the following subsections primarily describes On Limits monitoring information.

Table 2-1. Control System Monitoring (On Limits)

Type of Monitor	High-fault Level	High-warning Level	Low-warning Level	Low-fault Level	Minimum Response Time
Module Temperature	140 °F (60 °C)	130 °F (54 °C)	50 °F (10 °C)	40 °F (4 °C)	10 s
-4.5 Supply Voltage	-5.35 V	-4.9 V	-4.01 V	-.1 V	100 ~~[illegible]00~~ ms
-5.2 Supply Voltage	-6.18 V	-5.67 V	-4.63 V	-.1 V	100 ~~[illegible]00~~ ms
-2.0 Supply Voltage	-2.74 V	-2.64 V	-1.78 V	-.1 V	100 ~~[illegible]00~~ ms
Pressure	80 psig	75 psig	-4 psig	-8 psig	100 ~~[illegible]00~~ ms
Transformer Temperature	200 °F (93 °C)	190 °F (88 °C)	50 °F (10 °C)	40 °F (5 °C)	10 s
Power Supply Plate	110 °F (43 °C)	100 °F (38 °C)	50 °F (10 °C)	40 °F (5 °C)	10 s
In Transformer/In PS Plate/In Modules	90 °F (33 °C)	85 °F (29 °C)	50 °F (10 °C)	40 °F (5 °C)	10 s
Out Transformer/Out Modules	N/A	100 °F (38 °C)	50 °F (10 °C)	N/A	N/A
MG Phase to Phase Voltage (400 Hz)	250 Vac	229 Vac	187 Vac	104 Vac	100 ~~400~~ ms
MG Phase to Neutral Voltage (400 Hz)	144 Vac	132 Vac	108 Vac	60 Vac	100 ~~400~~ ms
Low Temperature	N/A	N/A	95 percent RH	N/A	1 minute
MG Hi Temp	N/A	N/A	Open Contact	N/A	N/A
Heat Exch Warning	N/A	N/A	Open Contact	N/A	N/A
Heat Exch Fault	N/A	N/A	Open Contact	N/A	10 s
4 V Self Test	4.08 V	4.06 V	3.94 V	3.92 V	100 ~~400~~ ms
± 12 V Self Test	± 13.2 V	± 12.6 V	± 11.4 V	± 10.8 V	100 ~~400~~ ms
± 5 V Self Test	± 5.5 V	± 5.25 V	± 4.75 V	± 4.5 V	100 ~~400~~ ms
Ground	100 mv	80 mv	N/A	N/A	100 ~~400~~ ms

Table 2-2. Control System Monitoring (Off limits)

Type of Monitor	High-fault Level	High-warning Level	Low-warning Level	Low-fault Level	Minimum Response Time
Module Temperature	150 °F (66 °C)	140 °F (60 °C)	40 °F (4 °C)	30 °F (-1 °C)	10 s
-4.5 Supply Voltage	-2.25 V	-1.75 V	N/A	N/A	100 ~~400~~ ms
-5.2 Supply Voltage	-2.6 V	-2.1 V	N/A	N/A	100 ~~400~~ ms
-2.0 Supply Voltage	-1.0 V	-.8 V	N/A	N/A	100 ~~400~~ ms
Pressure	80 psig	75 psig	-4 psig	-8 psig	100 ~~400~~ ms
Transformer Temperature	210 °F (99 °C)	200 °F (93 °C)	40 °F (5 °C)	30 °F (-1 °C)	10 s
Power Supply Plate	120 °F (49 °C)	110 °F (43 °C)	40 °F (5 °C)	30 °F (-1 °C)	10 s
In Transformer/In PS Plate/In Modules	90 °F (33 °C)	85 °F (29 °C)	40 °F (5 °C)	30 °F (-1 °C)	10 s
Out Transformer/Out Modules	N/A	110 °F (43 °C)	40 °F (5 °C)	N/A	N/A
MG Phase to Phase Voltage (400 Hz)	104 Vac	87 Vac	N/A	N/A	100 ~~400~~ ms
MG Phase to Neutral Voltage (400 Hz)	60 Vac	50 Vac	N/A	N/A	100 ~~400~~ ms
Low Temperature	N/A	N/A	95 percent RH	N/A	1 minute
MG High Temp	N/A	N/A	Open Contact	N/A	N/A
Heat Exch Warning	N/A	N/A	Open Contact	N/A	N/A
Heat Exch Fault	N/A	N/A	Open Contact	N/A	10 s
4 V Self Test	4.08 V	4.06 V	3.94 V	3.92 V	100 ~~400~~ ms
± 12 V Self Test	± 13.2 V	± 12.6 V	± 11.4 V	± 10.8 V	100 ~~400~~ ms
± 5 V Self Test	± 5.5 V	± 5.25 V	± 4.75 V	± 4.5 V	100 ~~400~~ ms
Ground	100 mv	80 mv	N/A	N/A	100 ~~400~~ ms

Monitoring is done when the computer system is off to detect fault conditions due to a variety of causes. The computer system is not allowed to power on as long as a fault condition remains. A high-temperature fault can result from excessive residual heat on the modules and power supplies following computer system operation. The control system also detects a fault if only a sensor is bad. For example, a high-temperature fault for a power supply may result when a temperature sensor on a power supply sensor is shorted. Low-temperature faults result when a sensor is open.

Module Temperature

Monitoring for excessively high module temperatures prevents damage to components and melted solder joints. Very low temperatures at the module cause moisture condensation that can lead to a short. Operating temperatures of the mainframe modules are monitored by a thermistor probe connected through a plated hole in the module to the ground layer of each plate of the double module. Temperature sensing for each of the 40 double modules in the mainframe is accomplished by sensing the primary and backup thermistor probes on both module plates. (There are 162 thermistors on the CPU, memory, and system clock modules in the mainframe.)

The control system monitors a high-temperature fault at 140 °F (60 °C), and a high-temperature warning is measured at 130 °F (54 °C); a low-temperature warning is measured at 50 °F (10 °C), and a low-temperature fault is measured at 40 °F (4 °C). Temperature fault conditions (any fault condition) at the modules must be present for a required response time before the fault is detected by the control system. A response time of 10 s is required before a module temperature fault causes the computer system to power-down.

Power Supply Voltage

Monitoring the output of the power supplies insures against high voltages that can cause damage to components on a module. The control system monitors the voltages from all mainframe power supplies for high-voltage fault, high-voltage warning, low-voltage warning, and low-voltage fault conditions. A sense wire attached to each of the 12 chassis buses monitors the individual DC power bus voltages.

A response time of 400 ms is necessary for the -4.5 Vdc, -5.2 Vdc, and the -2.0 Vdc power supplies. For the -4.5 Vdc power supply the control system monitors a high-voltage fault at -5.35 Vdc and a high-voltage warning is measured at -4.9 Vdc; a low-voltage warning is measured at -4.01 Vdc and a low-voltage fault is measured at -.1 Vdc. For the -5.2 Vdc supply, the control system monitors a high-voltage fault at -6.18 Vdc and a high-voltage warning is measured at -5.67 Vdc; a low-voltage warning is measured at -4.63 Vdc and a low-voltage fault is measured at -.1 Vdc.

In the -2.0 Vdc supply the control system monitors a high-voltage fault at -2.74 Vdc and a high-voltage warning is measured at -2.64 Vdc; a low-voltage warning is measured at -1.78 Vdc and the low-voltage fault is measured at -.1 Vdc.

Dielectric Fluid Pressure

Monitoring dielectric fluid pressure is done to prevent high pressures that can result in ruptured cold plates, hoses, and damage to the dielectric fluid pump. Low dielectric fluid pressure can result in excessively higher temperatures of modules and power supplies because of the lack of coolant flow. The pressure of dielectric fluid flowing in the mainframe is measured with pressure transducers at the input and output manifolds of the mainframe, within the power supplies, and in the power supply plate.

Dielectric fluid pressure monitored by the control system includes a high-pressure fault measured at 80 psig, a high-pressure warning measured at 75 psig, a low-pressure warning measured at -4 psig, and a low-pressure fault measured at -8 psig. The high- and low-pressure faults have a response time of 400 ms.

Transformer, Power Supply Plate, and Inlet/Outlet Manifold Temperatures

The control system monitors temperatures of the -4.5 Vdc, -5.2 Vdc, and -2 Vdc power supplies using a thermistor probe located in the choke area on top of the power supply. A high-temperature fault is measured on the power supplies at 200 °F (93 °C); a high-temperature warning is measured at 190 °F (88 °C). Low-temperature warnings and low-temperature faults are measured at 50 °F (10 °C) and 40 °F (5 °C), respectively. The response time for the temperature faults at the power supplies is 20 seconds.

The temperature of dielectric fluid in the power supply plate is also monitored by thermistor probes located at the bottom, top, and center of the power supply plate. Temperature monitoring is done to detect a high-temperature fault occurring at 110 °F (43 °C) and a high-temperature warning at 100 °F (38 °C). A low-temperature warning and low-temperature fault are measured at the power supply plates at 50 °F (10 °C) and at 40 °F (5 °C), respectively. The response time for inlet and outlet dielectric fluid temperature faults is 20 seconds.

Thermistor probes monitor the temperature of dielectric fluid flowing through the inlet manifolds of the transformers, power supply plates, and the modules. A high-temperature fault is measured at 90 °F (33 °C) and a high-temperature warning is measured at 85 °F (29 °C); a low-temperature warning is measured at 50 °F (10 °C) and a low-temperature fault is measured at 40 °F (5 °C). The response time for the fault conditions is 20 seconds.

The outlet manifold temperature of dielectric fluid flowing from the transformers and modules is monitored by thermistor probe with a high-temperature warning occurring at 100 °F (38 °C), and a low-temperature warning at 50 °F (10 °C). (There are no high and low fault conditions provided.)

Motor Generator Set (MGS) Voltage

The output of the MGS is monitored to insure against high voltages that can result in damage to the linear power supplies in the mainframe. Low output of the MGS results in noise on the output of the power supplies and insufficient power supply output. MGS voltages are measured phase to neutral; a measurement is taken from each of the three phases of the output voltage to neutral. A high-voltage fault is monitored at 144 Vac, and a high-voltage warning is measured at 132 Vac; a low-voltage warning is measured at 108 Vac and a low-voltage fault is measured at 60 Vac. The response time for a MGS voltage fault is 400 ms.

MGS phase-to-phase output voltages are monitored with a high-voltage fault measured at 250 Vac, and a high-voltage warning at 229 Vac; a low-voltage warning is measured at 187 Vac and a low-voltage fault is measured at 104 Vac. The voltage measurements are taken between two of the three phases of the MGS output. The response time for the phase-to-phase voltage is also 400 ms.

System Monitoring

The control system monitors sensors that are not shown with a group label on the control system console. The types of sensors that are monitored include: Low Temperature, MG High Temperature, Heat Exchange Warning, and Heat Exchange Fault.

Low Temperature

A Low Temperature sensor monitors condensation that has formed at the mainframe. A moisture sensor is located at the intake manifold for the modules. With operation of the computer at room temperatures moisture condensation is not expected to be a problem. The response time for a low-temperature fault is 1 minute.

MG High Temperature 202° F

The MGS has a high-temperature thermostat that is monitored by the control system. The level of the MG High Temperature fault is determined by the manufacturer. The control system only senses for an open state of the thermostat. The computer system does not power down for an MG High Temperature fault.

Heat Exchange Warning

The Heat Exchange Warning indicator lights and an alarm sounds when either a Low Liquid Level or Compressor Fault signal is sent from the Heat Exchange Unit (HEU). Further description of the Heat Exchange Warning condition is contained in "HEU Control System Indicators" in Section 4. The computer system does not power down for a Heat Exchange Warning condition.

Heat Exchange Fault

A Heat Exchange fault is a high-pressure fault measured by sensors at the dielectric fluid pump on the HEU. The control system monitors for a ~~120~~ 125 psig value. The response time for a Heat Exchange fault is 10 seconds.

Self Tests

The control system monitors self tests that are done to verify reference voltages used on the control system modules. The response time for all self tests is 400 ms. There is an internal 4.0 Vdc reference test that monitors a high-voltage fault at 4.08 Vdc, a high-voltage warning at 4.06 Vdc, a low-voltage warning at 3.94 Vdc, and a low-voltage fault at 3.92 Vdc.

The internal ±12 Vdc reference test monitors a high-voltage fault at ±13.2 Vdc, a high-voltage warning at ±12.6 Vdc, a low-voltage warning at ±11.4 Vdc, and a low-voltage fault at ±10.8 Vdc, respectively. An internal ±5 Vdc reference check monitors for a high-voltage fault at ±5.5 Vdc, a high-voltage warning at ±5.25 Vdc, a low-voltage warning at ±4.75 Vdc, and low voltage fault at ±4.5 Vdc. A ground test monitors for a high-voltage fault at 100 mv and a high-voltage warning at 80 mv.

FAULT CONDITIONS

The occurrence of a fault on a sensor does not always cause the CRAY Y-MP computer system to power down. A system fault is the result of certain required ANDed or ORed conditions of the primary and backup sensors of the A and B scanners on the control system. A fault on both the primary and backup sensors are required on one scanner if there is an ANDed condition. For example, a minimum of both the scanner A primary and backup sensors, or both the scanner B primary and backup sensors must sense faults before alarm and power-down circuitry is enabled. For an ORed condition, only the presence of a fault on either scanner A's or scanner B's primary or backup sensors is required.

WARNING AND POWER-DOWN SEQUENCES

The alarm and power-down sequence of the CRAY Y-MP computer system varies depending on whether the machine is in field or service mode. If a fault occurs in field mode, the alarm sounds; after the minimum response time, the power-down sequence begins. The MGS exciter disengages and the MGS motor begins to power off within 3 to 4 seconds. A signal is sent to power down the RCU-1 and HEU at this time.

When in service mode, the MGS exciter disengages and the RCU-1 and HEU begin to power down when a system fault occurs. The MGS motor is powered off within 1 hour.

CONTROL SYSTEM CONSOLE OPERATION

The control system console displays the status of all scanner information that the main processor reads from memory. Displayed fault information is useful as an aid when troubleshooting. An FE service panel and an operator panel are located on the control system console above the circuit breaker and voltage adjust panel of the mainframe. (Refer to Figure 2-1, CRAY Y-MP Control System Console.)

Service Panel

The service panel selects and views faults that occurred prior to a fault or mainframe power-down. Fault information is not only displayed, but also retained in battery-backed RAM memory to aid troubleshooting. In the event the computer system unexpectedly powered down, the FE is able to detect the fault using the Scanner A or B, Memory Display, and Primary and Backup Fault switches located on the control system console.

The control system console service panel is located behind a cover at the top of the Display module. There are ten switches provided on the panel with the following functions:

Switch	Switch Function
• Start On Fault	Causes a system power up despite a fault
• Cooling Bypass	Turns on a cooling pump in the HEU without initiating a power-on sequence
• Remote	Enables a system power up or power down from a remote site
• MG Adjust	Adjusts the output voltage of the MGS
• Scanner A/B (2 switches)	Displays information only from scanner A or only from scanner B

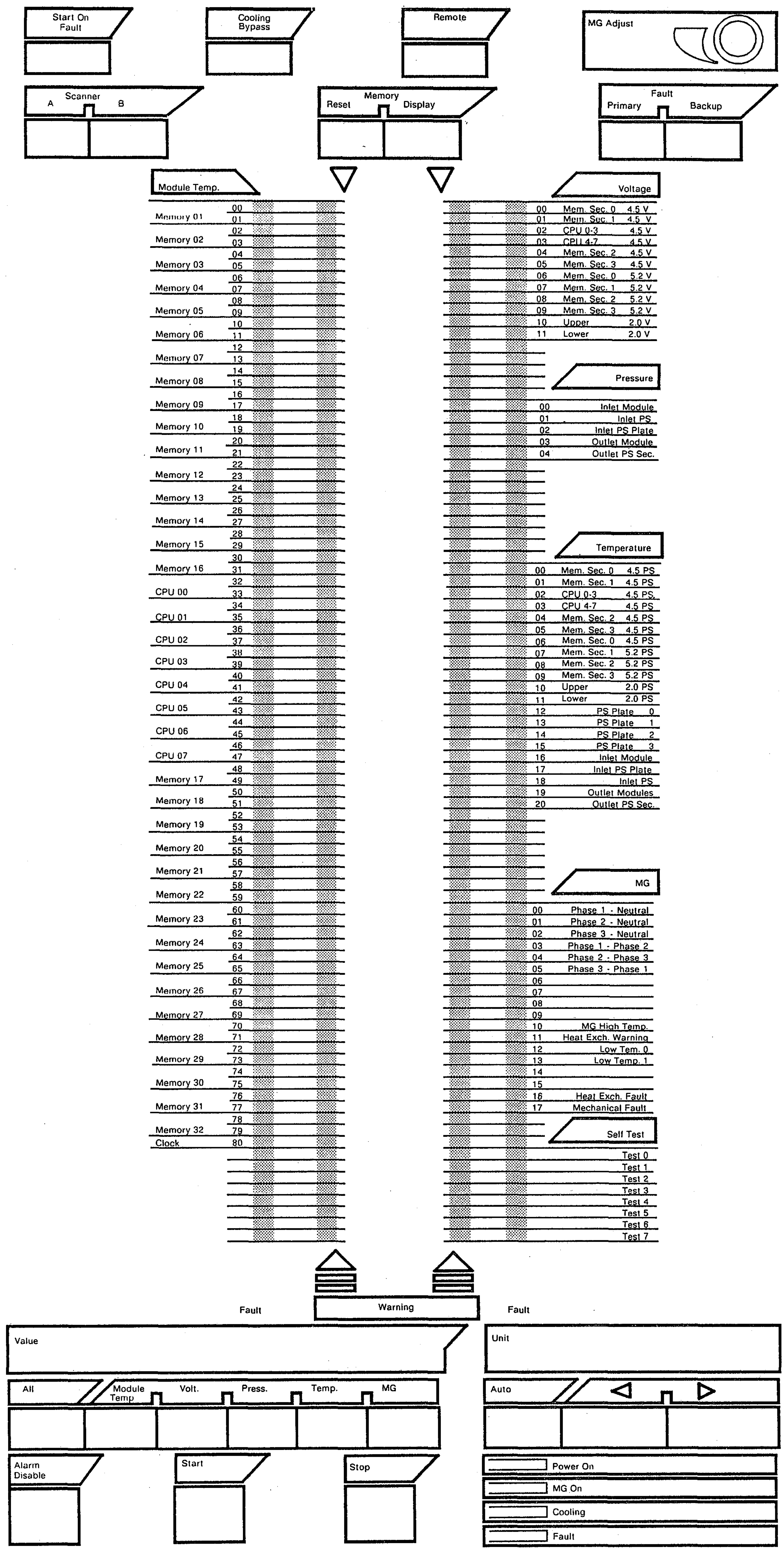


Figure 2-1. CRAY Y-MP Control System Console

Switch	Switch Function
• Memory Reset	Manually clears scanner memory
• Memory Display	Displays all faults recorded by the scanner since scanner memory was last cleared
• Primary Fault	Displays faults recorded on primary sensors of the scanner
• Backup Fault	Displays faults recorded on backup sensors of the scanner

Operator Panel

The operator panel on the control system console contains three system control switches: Start, Stop, and Alarm Disable. Press the Start switch to power up the MGS, refrigeration system, and mainframe. A successful power up is shown by the Power On, MG On, and Cooling indicators being lit. Press the Stop switch to power down the MGS, refrigeration system, and mainframe. The Stop switch also extinguishes the MG On, Cooling, Power On, and (if lit) the Fault indicators. The Alarm Disable switch turns off the audible alarm until the occurrence of the next fault.

There are two 7-segment LED displays called Value and Unit. These displays show information resulting from the selection of any of the the eight scanner control switches located below this LED panel. The Value indicator is a digital display of the value of control system sensor information. The Unit indicator shows the number of the unit being scanned; these unit numbers are shown on Figure 2-1.

The following eight scanner control switches are located on the operator panel:

Switch	Switch Function
• All	Scans control system sensors
• Module	Scans module temperatures
• Volt.	Scans DC voltages
• Press..	Scans coolant pressures
• Temp.	Scans other system temperatures
• MG	Scans the MGS output voltage
• Auto	Causes continuous scanning of the selected sensor group
• > (Up)	Causes scanning of the selected sensor group in ascending order, for example, 0 to 80; holding down the switch causes continuous scanning
• < (Down)	Causes scanning of the selected sensor group in descending order, for example, 80 to 0; holding down the switch causes continuous scanning

THEORY OF OPERATION

This subsection describes the theory of operation for the control system. The control system is microprocessor-based and consists of three modules mounted on the mainframe above the voltage adjust and circuit breaker panel. The YLOG, YAN, and Display modules make up the control system.

The YLOG module contains two scanner microprocessors (scanner A and scanner B) and a main microprocessor that interfaces each of the scanners. Each scanner monitors a set of primary and back-up sensors. The scanner microprocessor reads information from the sensor and determines whether normal operating limits are maintained or exceeded. The status of all information is displayed on the Display module LED panel once it is stored in shared memory and read by the main microprocessor.

The scanner A or scanner B 8-bit microprocessor addresses a series of one-of-eight multiplexers that essentially form a one-of-192 multiplexer. (Refer to the CRAY Y-MP Control System Block Diagram in Figure 2-2 to locate the one-of-192 multiplexer and the address decode logic functional blocks.) When the multiplexer is addressed, the microprocessor selects one of a possible 192 channel pairs in the system. (There are a possible 192 scanner A and B primary sensors and a possible 192 scanner A and B backup sensors that make up the channel pairs in the control system circuit.)

The scanner microprocessor works in conjunction with control signals provided by decode logic located on the YLOG module to select a one-of-eight multiplexer chip containing the channel to scan. (Initially, the microprocessor program selects channel 0.) The microprocessor writes to the address latch, which provides the ASEL/BSEL control signals for the multiplexer. Once a channel is selected, the value of the signal is written to one of the two primary and backup Analog to Digital (A/D) converters.

When the analog signal reaches the A/D converter, it takes 80 microseconds to complete the conversion of the signal to digital information. The scanner microprocessor compares the value of the digital information to the threshold value for that sensor to determine whether the value is at a point where either a fault or warning occurs, or if it is within normal operating limits. If the value is at a fault or warning point, a counter keeps track of how long the error was present. A minimum response time (refer to Table 2-1) is necessary before a fault causes the computer system to begin to power down. The status of the operation is always written to the display located on the control console. In addition, fault information is written to 8 k of battery-backed RAM memory.

YLOG Module

The YLOG module is is an eight-layer board located behind the Display module above the voltage adjust and circuit breaker panel on the CRAY Y-MP mainframe. The YLOG module contains the following functional blocks: (The following subsections describe the functional blocks in detail.)

- Main Microprocessor
- Scanners A and B Microprocessors
- Relays K1 through K14
- Battery Memory
- Shared (Common) Memory
- A/D Converter
- Address Decode Logic

Main Microprocessor

The control system main microprocessor is the same type of microprocessor used for the scanners; however, the functions of the main microprocessor and scanner

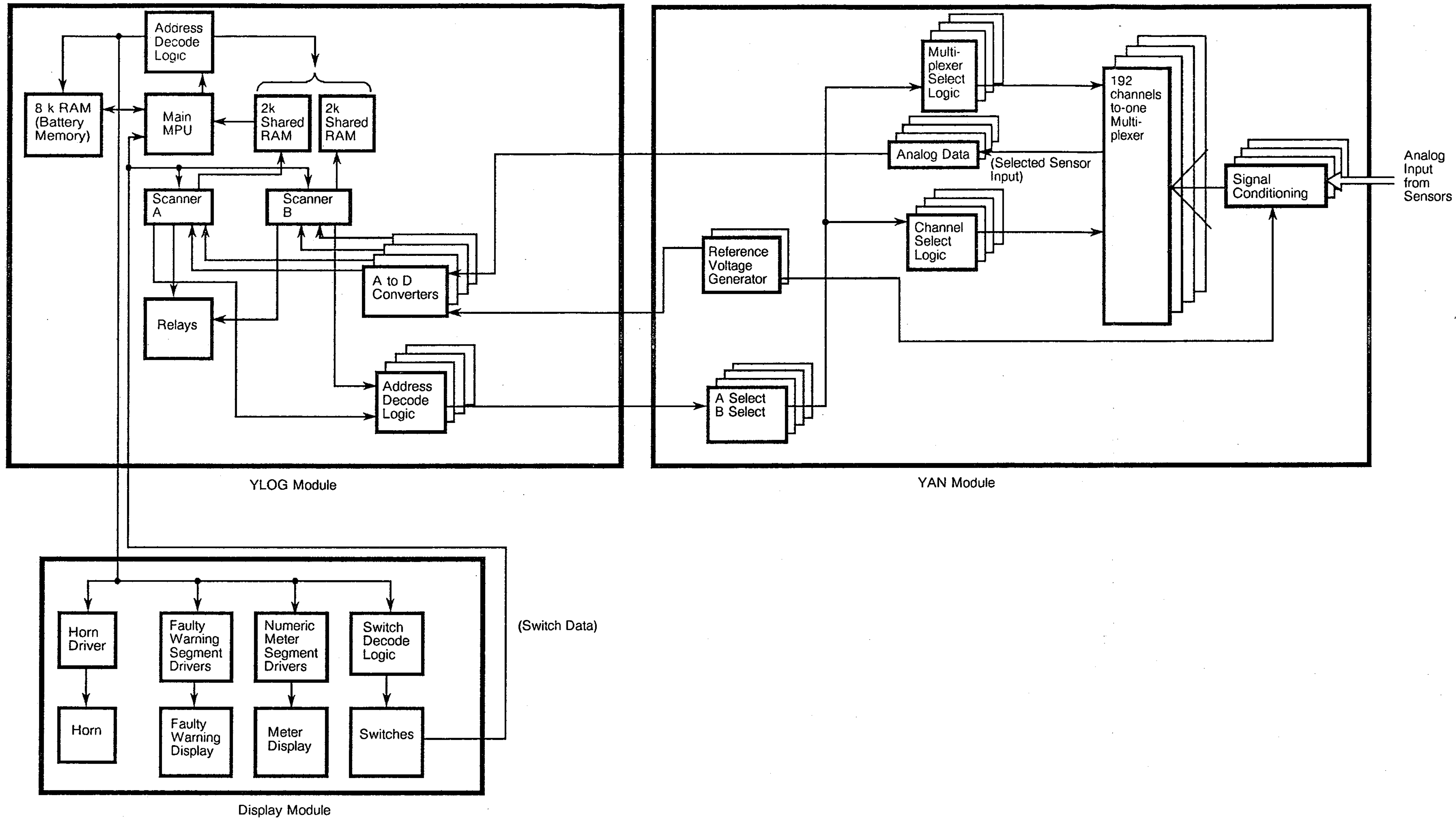


Figure 2-2. CRAY Y-MP Control System Block Diagram

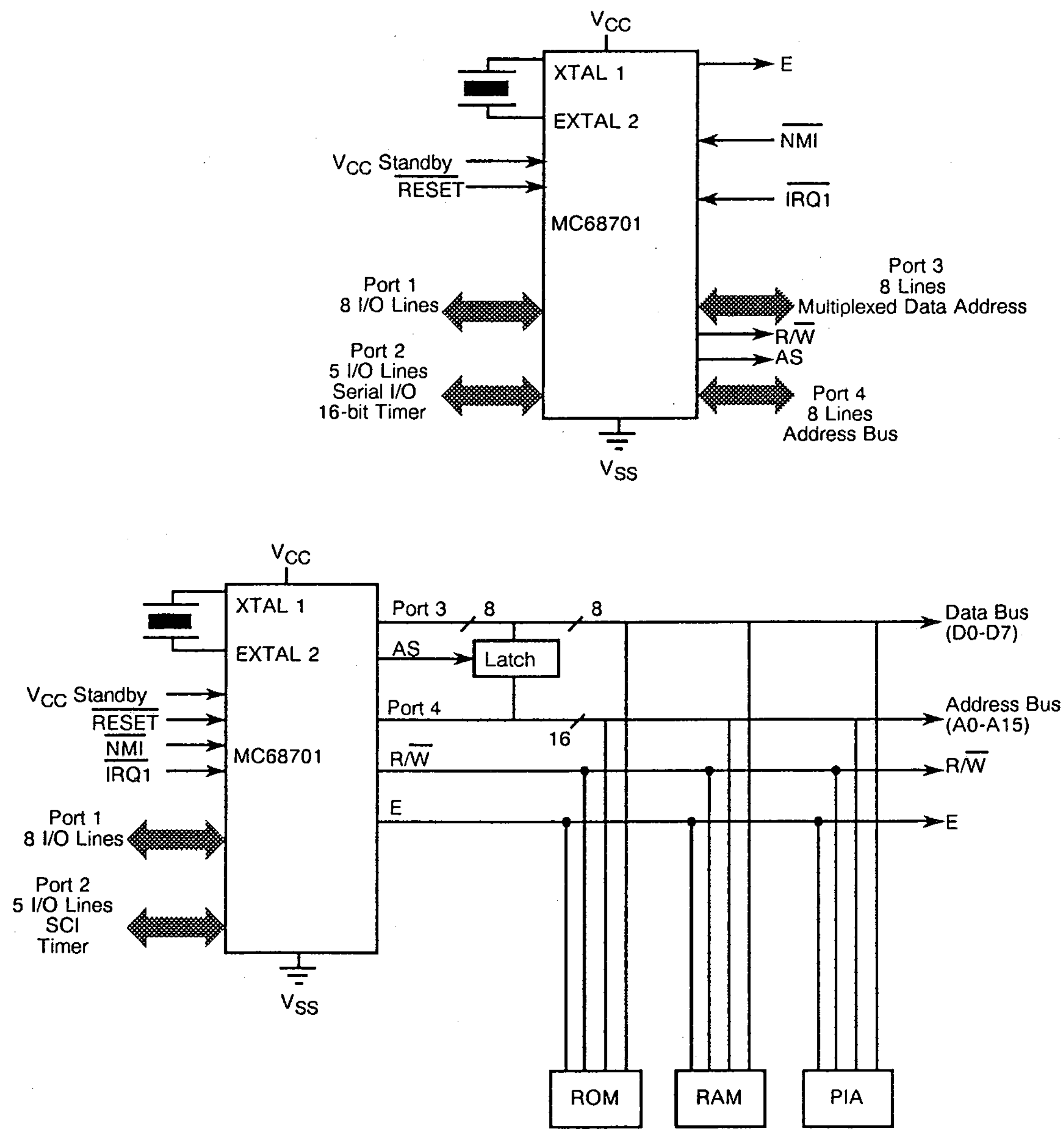


Figure 2-3. Main/Scanner Microprocessor Configuration

microprocessors differ. Figure 2-3 shows a typical configuration of either microprocessor, which can address 64 k bytes of memory.

The microprocessor has three 8-bit ports and one 5-bit port. (Refer to Figure 2-4, Main/ Scanner Microcomputer Block Diagram, for an illustration of the ports.) Port 1 (8 bits) is not used in the main microprocessor. Port 2 (5 bits) is used for mode select and it also maintains the local and remote alarms. Port 2 also receives the Start and Stop signals

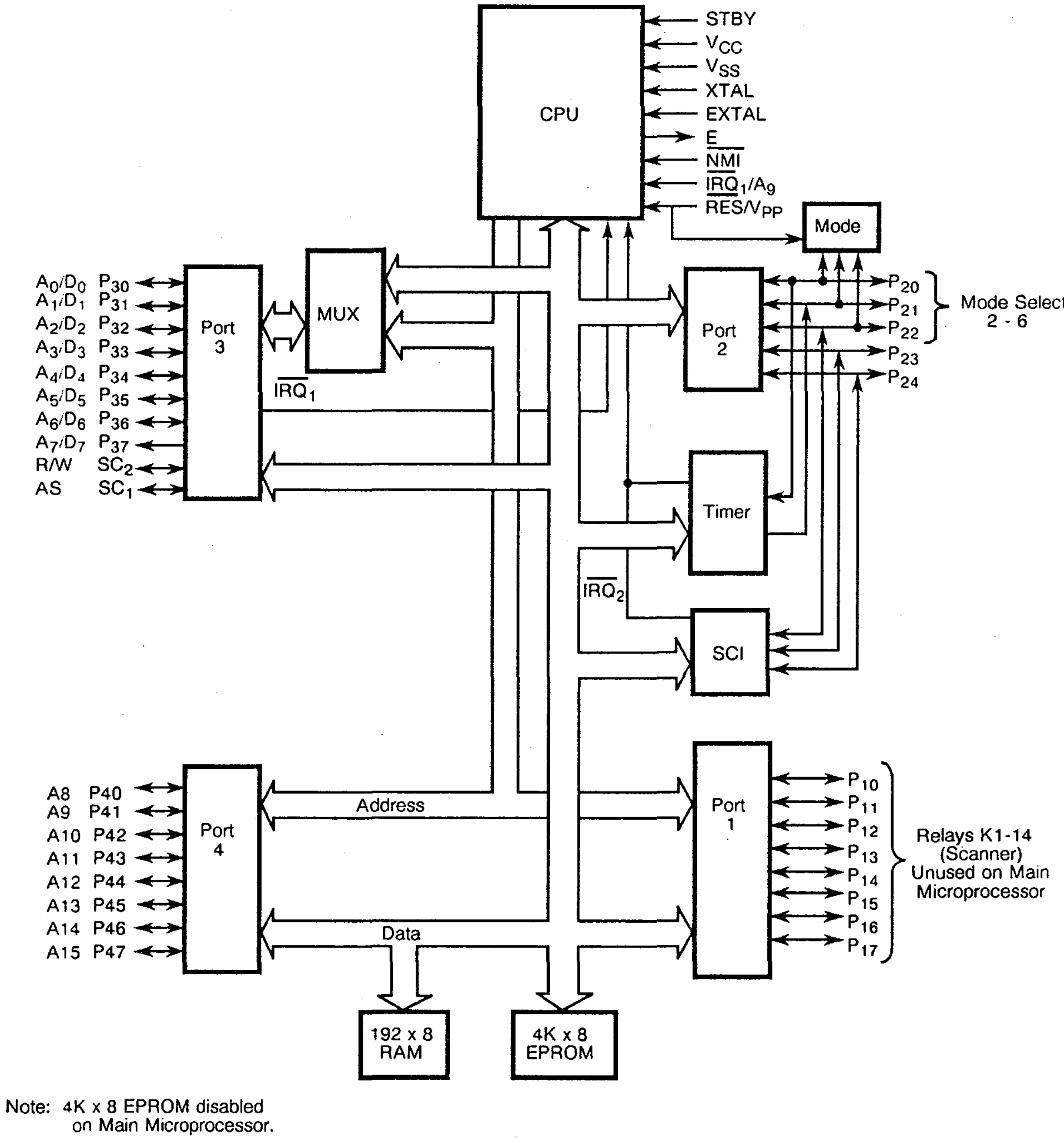


Figure 2-4. Main/Scanner Microprocessor Block Diagram

from the control system console. The Non-Masked Interrupt (NMI) signal is incorporated as the Stop signal.

In Figure 2-3, Port 3 (8 bits) is shown as a time-multiplexed address/data bus. Port 3 handles the lower 8 bits of address information. The Address Strobe (AS) signal can be used to control a transparent D-type latch to capture addresses A0 through A7. This allows Port 3 to function as a data bus when the E signal is high. Port 4 (8 bits) provides address lines A8 to A15.

Scanners A and B Microprocessors

The scanner microprocessor reads information from sensors it addresses on the YAN module. Analog input signals are converted to digital information by scanner A/D converters. This information is transferred to shared memory before it is read by the main microprocessor and displayed on the Display module. The two scanners in the control system perform identical functions. Data from scanner B verifies data from scanner A, so that fault information is validated before warning and power-down sequences are initiated. Port 1 of the scanner microprocessor controls relays K1 through K14 in the control system. Port 2 sets the microprocessor operating mode and is used to decode and sense faults. As on the main microprocessor, Port 3 of the scanner microprocessor is again used for the data bus and the lower 8 bits of the address information. Port 4 is used for the upper 8 bits of address information.

Relays K1 through K14

As mentioned previously, Port 1 of the scanner microprocessor controls the K1 through K14 relays contained on the YLOG module. The relays operate in the following manner:

RELAY	FUNCTION
• K1	Turns on the MGS motor
• K2	Turns on the MGS exciter
• K3	Turns on the HEU and RCU
• K4 through K6	Not Used
• K7	Turns off the main 400-Hz circuit breaker
• K8	Prevents the computer system from powering up once it has powered down
• K9	Turns on the remote alarm
• K10	Enables both Start and Stop switches
• K11	Supplies power to other control system relays
• K12	Enables remote operation of the computer system
• K13	Turns the local alarm on and off
• K14	Prevents the control system microprocessor from circulating dielectric fluid through the mainframe without first pressing the Cooling Bypass switch

Battery-backed RAM Memory

Battery-backed RAM memory on the YLOG module consists of an 8 k × 8-bit RAM memory chip. This memory stores all fault information to aid troubleshooting efforts in the event the system powered off and data is lost. The chip receives operating voltage from two 3 Vdc batteries located on the YLOG module. All fault information and the contents of the battery memory can be seen by operating the Memory Display switch on the FE service panel of the control system console.

2 k Shared (Common) Memory

Scanner A and scanner B each have a 2 k × 8-bit memory device on the YLOG module that serves as shared memory with the main microprocessor. All fault and status information received from the sensors during normal operation is written to the shared memory. The main microprocessor reads this information and displays it on the LED display panel of the Display module.

Analog to Digital (A/D) Converter

Two CMOS Analog to Digital (A/D) converters are used for each scanner (A and B) in the control system. Each scanner has an A/D converter that monitors a set of primary sensors and a second A/D converter that monitors a set of backup sensors in the computer system.

The A/D converter receives analog inputs (0 to 4 Vdc) from sensors located throughout the computer system and converts them to digital information that can be read by the scanner microprocessor. This information is later loaded into memory and read by the main microprocessor.

Address Decode Logic

Address decode logic is used by the main processor to select locations in memory containing warning/fault and status information written by the scanner. These memory mapped locations must be selected by the main processor before information can be displayed on the Display module. Decode logic allows the main microprocessor to select memory mapped switches and switch banks on the Display module during operator use.

Address decode logic consists primarily of five one-of-eight demultiplexer chips used to handle data from 16 different address lines. The lower 8 bits of address information is sent from the microprocessor to a tri-state latch. The upper 8 bits of address information is sent to a tri-state driver/receiver. The addresses are decoded to hexadecimal values ranging from 0000 to FFFF.

The address decode logic on the scanners is similar to that used for the main microprocessor. The purpose of the address decode logic for the scanners is to provide the ASEL/BSEL signals that enable selection of specific multiplexers and channels on the control system. The logic contains two one-of-eight decoders. The lower 8 bits of address information from the scanner microprocessor is again sent to an address latch. The upper 8 bits of address information are sent to a driver/receiver. The addresses are decoded to hexadecimal values, such as BE0C to 37FF.

YAN Module

The YAN module is an ten-layer board located behind the YLOG module above the circuit breaker and voltage adjust panel on the mainframe chassis. It contains the following features:

- Multiplexer/Channel Select Logic
- Signal Conditioning
- Reference Voltage Generator
- One-of-Eight Multiplexers

Multiplexer/Channel Select Logic

The scanner microprocessor sends data to a tri-state address latch on the YLOG module to generate the signals that select specific multiplexers and channels in the control system. The microprocessor writes 4 bits of address information into the latch for the number of the channel it desires to select. The remaining bits from the eight bits of address information go to a one-of-16 decoder chip located on the YAN module. The outputs of the decoder chip are the G signals that select the individual one-of-eight multiplexer chip.

Signal Conditioning

The YAN module uses voltage divider networks to provide signal conditioning for sensor inputs throughout the control system. The networks are located immediately after the module connectors and reduce the input voltage to a usable level for the control system logic.

Analog signals sent from power supply buses are reduced by a voltage divider circuit to 1/5 their original value. The signals from pressure transducers are also reduced to 1/5th their value. MGS signals are reduced to 1/200th of their original value, considering they are received at the YAN module at their full phase-to-phase value (approximately 208 Vac). The 208 Vac signal is also rectified and the output of the rectifier is between 0 Vdc and 1.8 Vdc.

Reference Voltage Generator

The reference voltage generator on the YAN module generates 4 Vdc to provide the reference current for the A/D converter. The generator also provides the supply voltage for the thermistor probes located on the modules, power supplies, and power supply plates.

One-of-192 Multiplexer

The one-of-192 multiplexer receives the control signals ASEL/BSEL and INH through address decode logic on the YLOG module. The control signals allow the microprocessor to select one-of-192 analog inputs from sensors located throughout the system. The multiplexer accommodates up to 192 channel pairs used throughout the CRAY Y-MP computer system. (There is one channel pair for scanner A primary and backup sensors and one channel pair for the scanner B primary and backup sensors.)

Display Module

The Display module is a six-layer board located at the back of the CRAY Y-MP computer mainframe in an arrangement that also contains the YAN and YLOG modules. The Display module is mounted in front of the YAN and YLOG modules on a hinged assembly to allow access to each module. The following are the major functional blocks of the Display module:

- Fault/Warning Segment Drivers
- Fault/Warning Segment Display

- Horn driver
- Horn
- Switch Decoding
- Switches

Fault/Warning Segment Drivers

Fault and warning address data is sent from the main microprocessor to the Display module where it is decoded to select specific LEDs that show the system location and value of a fault or warning. The display board contains a 7-segment LED display as well as individual LEDs. The fault and warning segment drivers consist of circuitry receiving the output of a one-of-eight decoder chip.

The inputs to the decoder chip, DA0 through DA5 (DA = Display Address) are provided by the 6 lower bits of address data from the main processor. DA0 through DA2 are used to select a bank of LEDs. DA3 through DA5 are used to select a specific LED. After the signal is decoded, it is sent an 8-by-7 multiplexer array circuit and used to select one of 56 row and column addresses.

Fault/Warning Display

The fault and warning displays consists of individual LEDs that display fault and warning information in addition to a 7-segment LED display that shows digital information giving the exact value of the fault or warning. The 7-segment LED displays of Value and Unit on the Display board show the level at which the fault or warning occurred and the unit number for the location of the fault. (Refer to "CONTROL SYSTEM CONSOLE OPERATION", in this manual for an explanation of Value and Unit.)

Horn Driver

The horn driver consists of an octal noninverting latch and peripheral driver array circuit that receives input signals from the main microprocessor. The main microprocessor sends a signal to the horn driver every time a fault or warning is detected in order to sound an alarm.

Horn

The horn is located on the Display module. If enabled, the horn sounds an audible signal when the microprocessor first detects a warning or fault.

Switch Decoding

Switch decoding is performed by the main microprocessor, which uses a one-of-eight decoder and tri-state latch and driver circuit to enable operation of specific switches.

Console Switches

There are 22 switches on the control system console. Refer to "CONTROL SYSTEM CONSOLE OPERATION" for the names and functions of the switches.

Sensors

The control system uses two types of sensors to measure temperatures and pressures in the CRAY Y-MP computer system: thermistor probes and pressure transducers. In addition, the control system monitors voltage by wiring directly to voltage sources. Thermistor probes are installed as primary and backup probes on each of the two plates of the CRAY Y-MP module. There are 162 thermistors on the 40 double modules and the system clock module in the mainframe (refer to Figure 2-5).

Thermistor probes are connected through a plated hole in the module to the ground layer. As the module gets colder, the voltage of the thermistor is reduced. A correspondingly lower-voltage analog signal is sent to the A/D converter. The warmer the thermistor, the higher the voltage level of the signal. The output of the thermistor probe does not vary beyond 0 to 4 Vdc.

Thermistor probes are also located on the power supplies, power supply plates, and at the inlet and outlet manifolds to the mainframe. Thermistor probes are also located at the inlet and outlet manifolds of the modules, power supply plates, and the power supplies.

Pressure transducers are used to measure dielectric fluid pressure at the inlet and outlet manifolds. Power supply inputs to the pressure transducers consist of both power (+10 Vdc) and ground.

The sensor output to the A/D converter is sent through a circuit containing precision operational amplifiers (op amps), comparators, and rectifiers. This circuit conditions the signal before it is converted to digital data read by the scanner.

Power Supplies

Three regulated on-board power supplies provide power to the control system. All power supplies are located on the YLOG module, have three terminals, and contain internal thermal overload and overcurrent protection. The following are the voltage regulators:

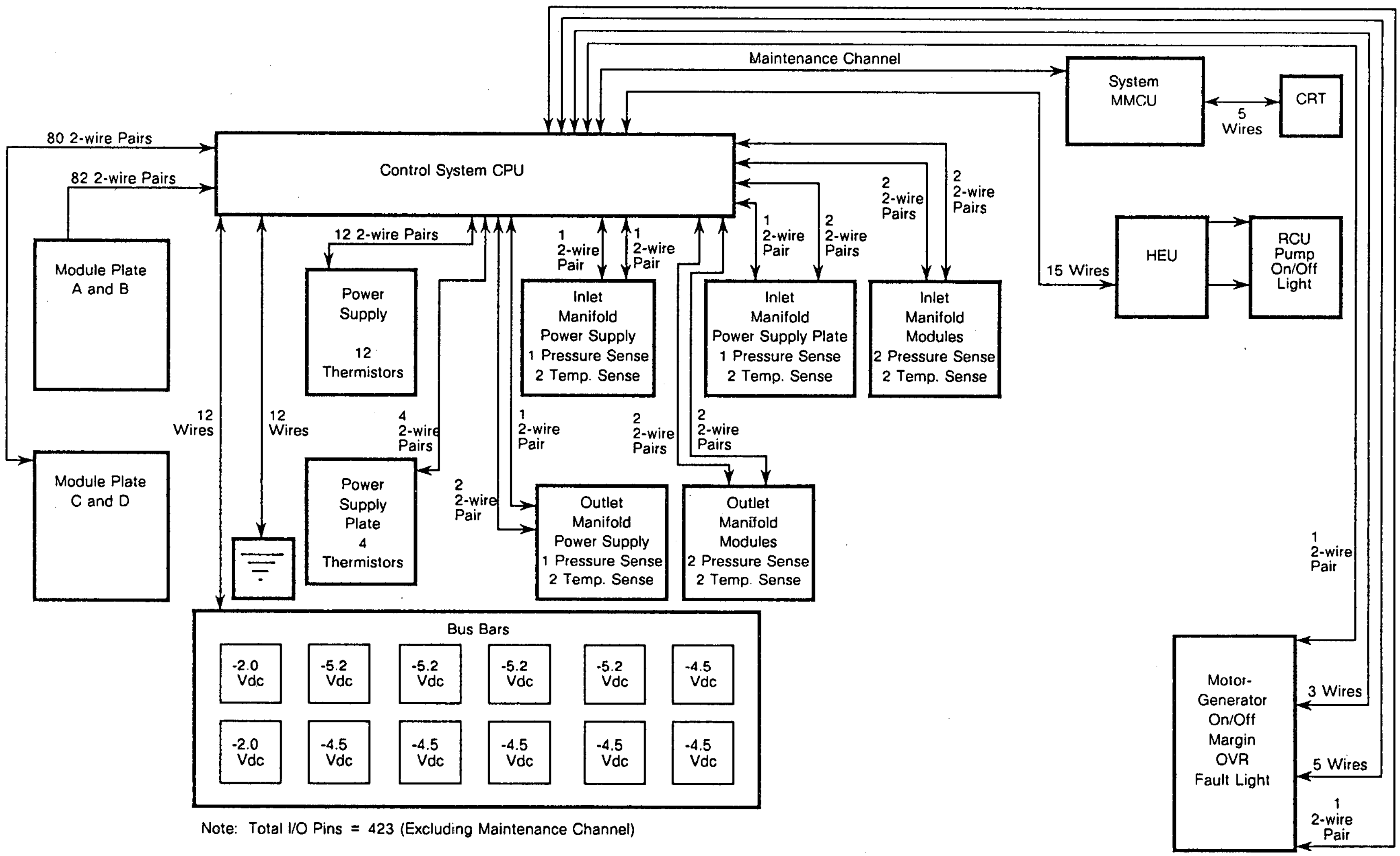
- ±12 Vdc power supply, which has output current in excess of 1.0 amp
- +5 Vdc power supply, which has output current in excess of 3.0 amps
- -5 Vdc power supply, which has output current in excess of 1.0 amp

Two unregulated power supplies, providing +12 Vdc and +24 Vdc, consist of rectifier circuits located on the YLOG board.

The supply voltages for the regulated and unregulated power supplies come from an external transformer located on the mainframe. The +18 Vac and +9 Vac supply voltages are the output voltages from a center-tapped 36 Vac, 60/50 Hz transformer.

The six voltages from the regulated and unregulated power supplies are used throughout the control system modules. CMOS circuitry uses +5 Vdc and op amps in the system use ±12 Vdc. LEDs on the Display module use +10 Vdc. The YLOG and

YAN modules use all six voltages from the power supplies, such as +20 Vdc for relays, and ±5 Vdc for the multiplexers and A/D converters.



Note: Total I/O Pins = 423 (Excluding Maintenance Channel)

Figure 2-5. Control System Sensor Locations

3 - POWER DISTRIBUTION

This section describes the power distribution in the CRAY Y-MP computer system. Information is provided on the power supplied to the mainframe by the Motor Generator Set (MGS) and the distribution of voltages by the individual linear power supplies. The mainframe uses three types of linear power supplies: -2.0 Vdc , -4.5 Vdc , and -5.2 Vdc. These power supplies provide the power necessary for all the circuitry on the CPU, memory, and system clock modules in the mainframe.

MOTOR GENERATOR SET (MGS)

The MGS used with the CRAY Y-MP computer system is a common frame type, with the motor and generator rotors stacked on a common shaft, and the motor and generator stators contained in a single frame (refer to *Instruction Manual for Cray Research, Inc.. Motor Generator Sets, 150 KW, 167 KVA, 60 to 400 Hertz*, provided by KATO Engineering).

The MGS has two functions: it isolates the system power from transients and fluctuations on the commercial power mains and it provides a frequency change from 50 Hz or 60 Hz to 400 Hz. The MGS also provides an override of 1/2 second in case of power sags from the commercial power lines.

The quietized MGS used with the CRAY Y-MP computer system reduces noise to 65 decibels. With operating noise this low, it is possible to locate the MGS within the computer room; however, a separate MGS room is recommended for the MGS installed with the CRAY Y-MP computer system.

The continuous 208-Vac, 400-Hz output of the MGS depends on monitoring by the CRAY Y-MP control system located at the back of the mainframe above the circuit breaker and voltage adjust panel. The MGS is remotely controlled by the control system, which ensures an MGS and computer system power-down in the event of faults because of temperature, pressure, or voltage fluctuations occuring in the computer system.

The MGS used with the CRAY Y-MP computer system for domestic installations is a 150-kw, 167-kva, 60-Hz model. An additional MGS plus a standby unit is necessary because an I/O Subsystem (IOS) and Solid State Storage Device (SSD) are installed. The input voltages from commercial power lines to the MGS are 460-Vac to 480-Vac, 3-phase, 60-Hz power.

MGS Power Distribution

Power is sent to the 400-Hz circuit breaker panel on the mainframe from the MGS (refer to Figure 3-1). A remote voltage sensing control cable is located at the mainframe for regulation purposes. Power to the mainframe breaker panel is 208 Vac, 3-phase, 400 Hz. The 208-Vac wiring set, which includes neutral and ground, is a 500 A, 5-wire set.

A 5-wire MGS control cable provides signals for the MGS exciter and MGS motor on/off circuits. (The control signals for the control cable are Motor On/Off, Exciter, and Neutral.) This cable also runs between the MGS 1, MGS 2, and the standby MGS. A shielded cable is provided for the MG Adjust potentiometer on the control system console.

MGS Operation

Power up the MGS by pressing the Start switch on the control system Display module. The pony motor starts and runs for 45 seconds to get the common shaft in the MGS spinning at 1,800 rpm. The pony motor then disengages and the 240-hp main motor engages. The main motor drives the generator within the MGS, which outputs 400 Hz, 208 Vac once a magnetic field is applied by the brushless exciter. The exciter receives its control voltage from the mainframe control system 1 minute after the Start switch is pressed.

MGS Configurations

System configurations and the electrical requirements of the MGS may vary, depending on the site requirements. The CRAY Y-MP mainframe requires 400-Hz power from a dedicated MGS. An additional MGS is provided for power for two IOSs and an SSD. An MGS is placed in standby mode for use as the reserve unit.

Refer to the *CRAY Y-MP Series Hardware Site Planning Reference Manual (HR-4000)* for other details of configurations.

MGS Operating Characteristics

The following are characteristics of the MGS motor:

- Maximum power rating: 240 hp
- Motor speed: 2,920 rpm at full load
- Maximum running current: 390 A at full load

The generator in the MGS is designed with a brushless rotating exciter and a 3-phase rotating field. Other operating characteristics of the generator include:

- Temperature rise: 202 °F (95 °C) maximum
- Heat rejection at full load: 115,000 BTU per hour, maximum
- Allowable voltage transients: 15% maximum
- Inertial isolation: With a .5 second input power outage, the output voltage does not drop below 95% of the rated voltage at full load and the MGS continues to operate.

The following are physical features of the MGS:

- MGS weight: 7,500 lbs (3,375 kg)
- Height: 78 in. (198 cm)

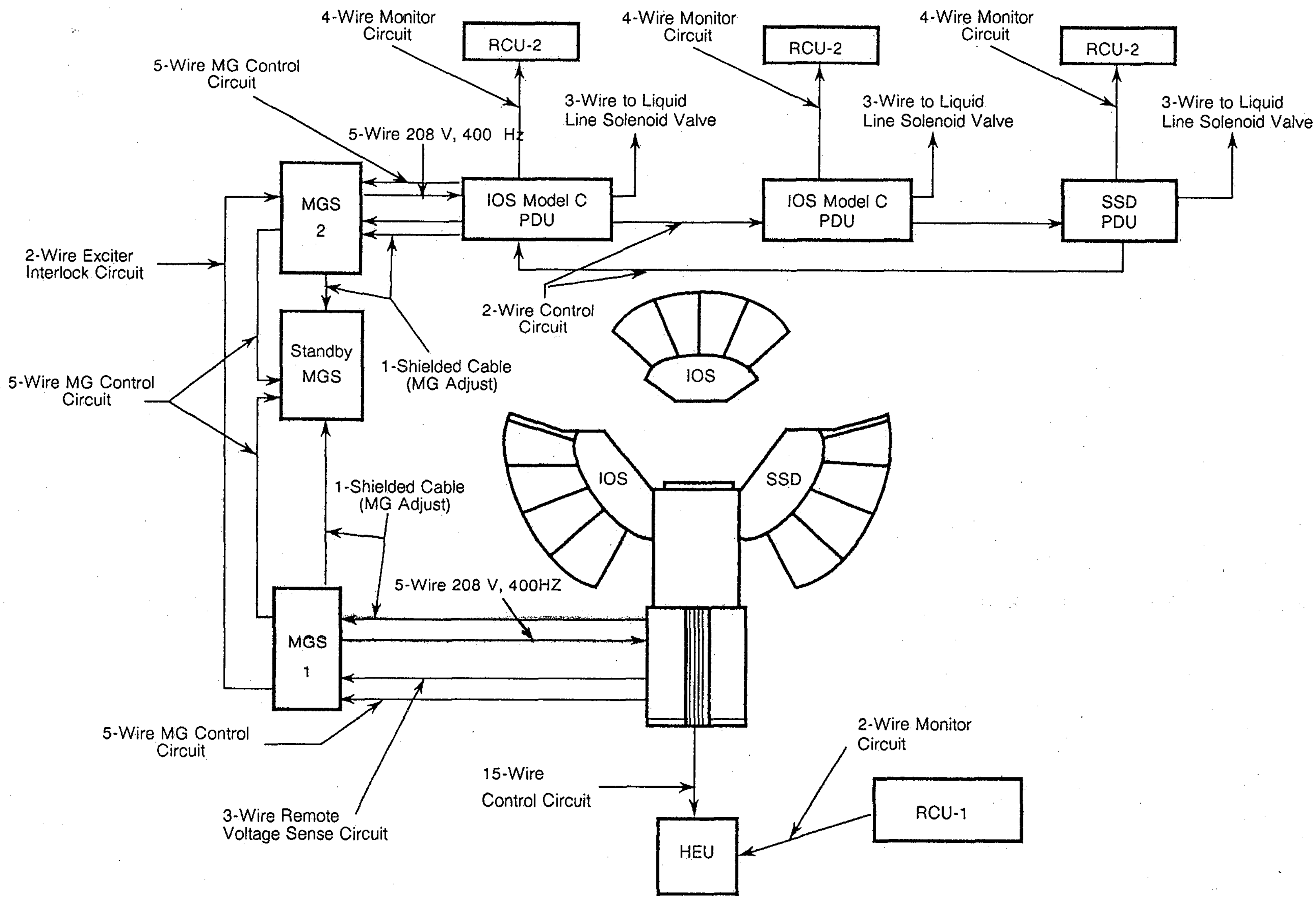


Figure 3-1. CRAY Y-MP MG Power Distribution

- Length: 97 in. (246 cm)
- Width: 45 in. (114 cm)

Protective Circuitry

The protective circuitry for the MGS includes motor overload protection; the motor starting system incorporates 3-phase overload protection. Phase monitoring is provided to prevent MGS operation if a phase failure or phase reversal occurs on the incoming power lines.

Control circuitry incorporates a protective feature capable of powering down either the normal (operating) or standby MGS if remote control voltage is lost for more than .5 seconds. Overvoltage protection is incorporated during startup, field excitation, or normal running operation. An overvoltage trip breaker removes voltage from the exciter field and the generator output. With the overvoltage limit set in the range of 210 to 240 Vac, the maximum RMS voltage at the generator output terminals is approximately 240 to 255 Vac.

LINEAR POWER SUPPLIES

Twelve linear power supplies are mounted to the power supply plate on either side of the CRAY Y-MP mainframe chassis. (Refer to Figure 3-2 for an illustration of the linear power supplies.) The supplies provide voltage to the chassis' 32 memory and eight CPU modules, in addition to the System Clock module. For a description of voltages used by the specific modules, refer to "BUSING" at the end of this section.

-2.0 Vdc Linear Power Supply

The -2.0 Vdc linear power supply provides the bias voltage (V_{TT}) for Emitter Coupled Logic (ECL) circuits in the CRAY Y-MP mainframe. The -2.0 Vdc power supply provides the terminating resistor layer of the module with voltage. Layer two of each module contains the 60-ohm terminating resistors used to terminate all output gates. ECL circuitry requires terminating all output gates.

Two 2800-A, -2.0 Vdc power supplies are located on the CRAY Y-MP mainframe. The supplies are mounted at the top and bottom of the power supply plate on the mainframe chassis on either side of four -5.2 Vdc power supplies.

-4.5-Vdc Linear Power Supply

The -4.5 Vdc linear power supply is used in the CRAY Y-MP computer system for supply voltage (V_{EE}) for the 2500-gate macrocell array chip contained on the CRAY Y-MP memory and processor modules. Each CPU module contains 312 macrocell array chips. The 148 macrocell array chips contained on each memory module are used for control logic.

Negative logic convention is used in reference to the macrocell array chip in a CRAY Y-MP system; that is, a logic 0 has a voltage range of -0.810 Vdc to -0.960 Vdc and a logic 1 has a voltage range of -1.65 Vdc to -1.95 Vdc.

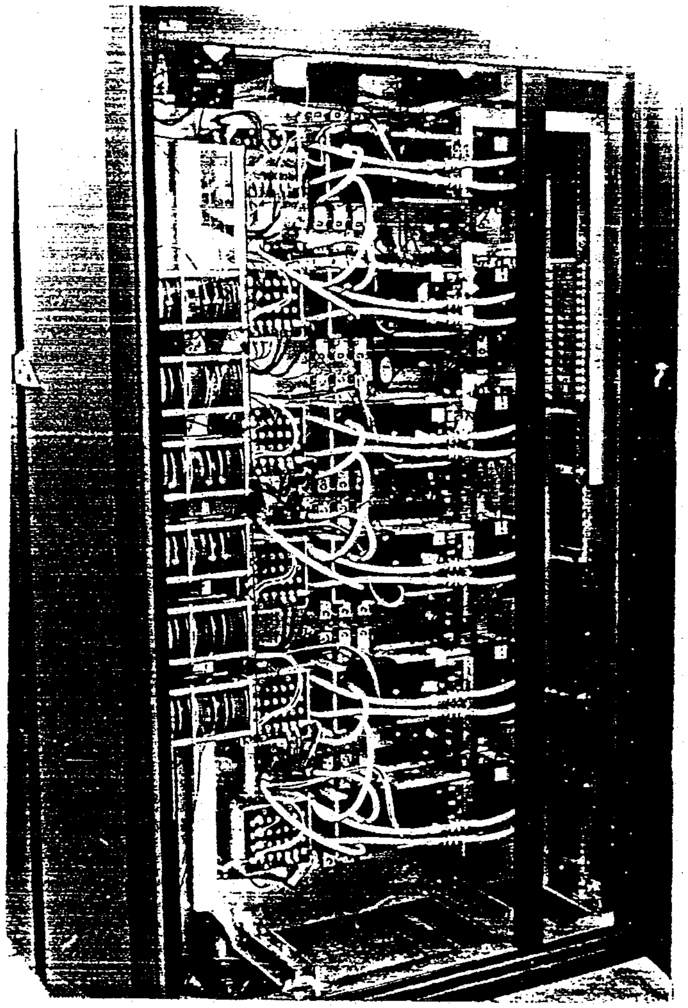


Figure 3-2. Linear Power Supplies in the CRAY-Y-MP Chassis

Six 2,200-A, -4.5-Vdc power supplies are used in the CRAY Y-MP computer system. The power supplies are located on the mainframe chassis opposite the -2.0 Vdc and -5.2 Vdc power supplies.

-5.2 Vdc Linear Power Supply

Working in conjunction with the -2.0 and -4.5 Vdc linear power supplies, the -5.2 Vdc linear power supply provides the operating voltage to the 64 k × 1 bit ECL-compatible RAM chips on the 32 memory modules in the system. Each memory module has 1152, 64 k × 1 bit RAM chips. Power is supplied to the module through a ground connector and three power buses at the rear of the module. Four 2,200-A, -5.2-Vdc power supplies are used in the system.

Linear Power Supply General Description

The 12-phase magnetic power supplies are an efficient, unregulated power supply. The MGS provides the necessary voltage regulation for all system power supplies. A variable transformer and buck transformer adjust input voltage to each linear power supply used in the mainframe. Inputs to the power supply are varied by turning an adjustment knob located on the voltage adjust and circuit breaker panel.

Total output power of the -5.2 Vdc linear power supply is approximately 11,440 W. The -2.0 Vdc power supply is approximately 5,600 W, and the -4.5 Vdc power supply is approximately 9,900 W. The -5.2 Vdc and -4.5 Vdc power supplies operate with a power factor of approximately .8. The -2.0 Vdc power supply has a power factor of .73.

Theory of Operation

The power supplies receive 3-phase, 400-Hz power (120 to 208 Vac or 160 to 208 Vac) from the MGS. The power supplies reduce the input voltage to -5.7 Vac, -5.0 Vac, or -2.5 Vac, and then rectify the voltage for direct current application. The final, rectified voltage is approximately .5 V less than the initially reduced A.C. voltage.

The smooth DC output voltage of the power supplies results from the power supply design that converts the 3-phase, 400-Hz input voltage to a 12-phase output voltage. The 400-Hz output voltage from the MGS provides a voltage source for each phase; A, B, and C. The three phases go to the primary windings of the transformer in the power supply, that step down the 400-Hz AC input voltage to the required output levels ; -5.7, -5.0, or -2.5 Vac.

The primary windings consist of an arrangement of three delta and three wye-type connections in the power supply (refer to Figure 3-3). This combination of delta and wye primary windings in the power supply, together with 400-Hz input power enables the stable output of the power supply. The maximum amount of ripple on the -5.2 Vdc power supply is approximately 100 mv peak-to-peak.

The power supplies use twelve 200 A diodes connected to the secondary windings of the power supply. The diodes, a Germanium type approximately 2.5 in. long, bolt to a transformer tap and also connect to the power supply plate for grounding purposes.

Stepped down voltage goes from the secondary windings and rectifier diodes in the transformer goes to three "balance" transformers. From there the voltage travels to an iron core choke, designed to reduce output ripple and transients from the power supply. The iron core choke provides filtering for heavy electrical loads. On the -5.2 Vdc and -4.5 Vdc supplies, ripple can be checked at a test point located before the iron core choke. Ripple measurements can also be taken after the voltage passes through the choke to test its proper operation.

A 60-k microfarad capacitor is located on the output of the -5.2 Vdc, -4.5 Vdc, and -2.0 Vdc power supplies. It is also used to suppress ripple.

Transient suppressors mount on the output bus of the -5.2-Vdc and -4.5-Vdc power supplies and connect to chassis ground to protect against voltage surges. The transient suppressor does not conduct current until the output voltage reaches -6.4 to -6.9 Vdc. Irreparable damage to the modules can result when voltages reach approximately -7.2 Vdc. When the transient suppressor conducts it shorts and may be destroyed. The

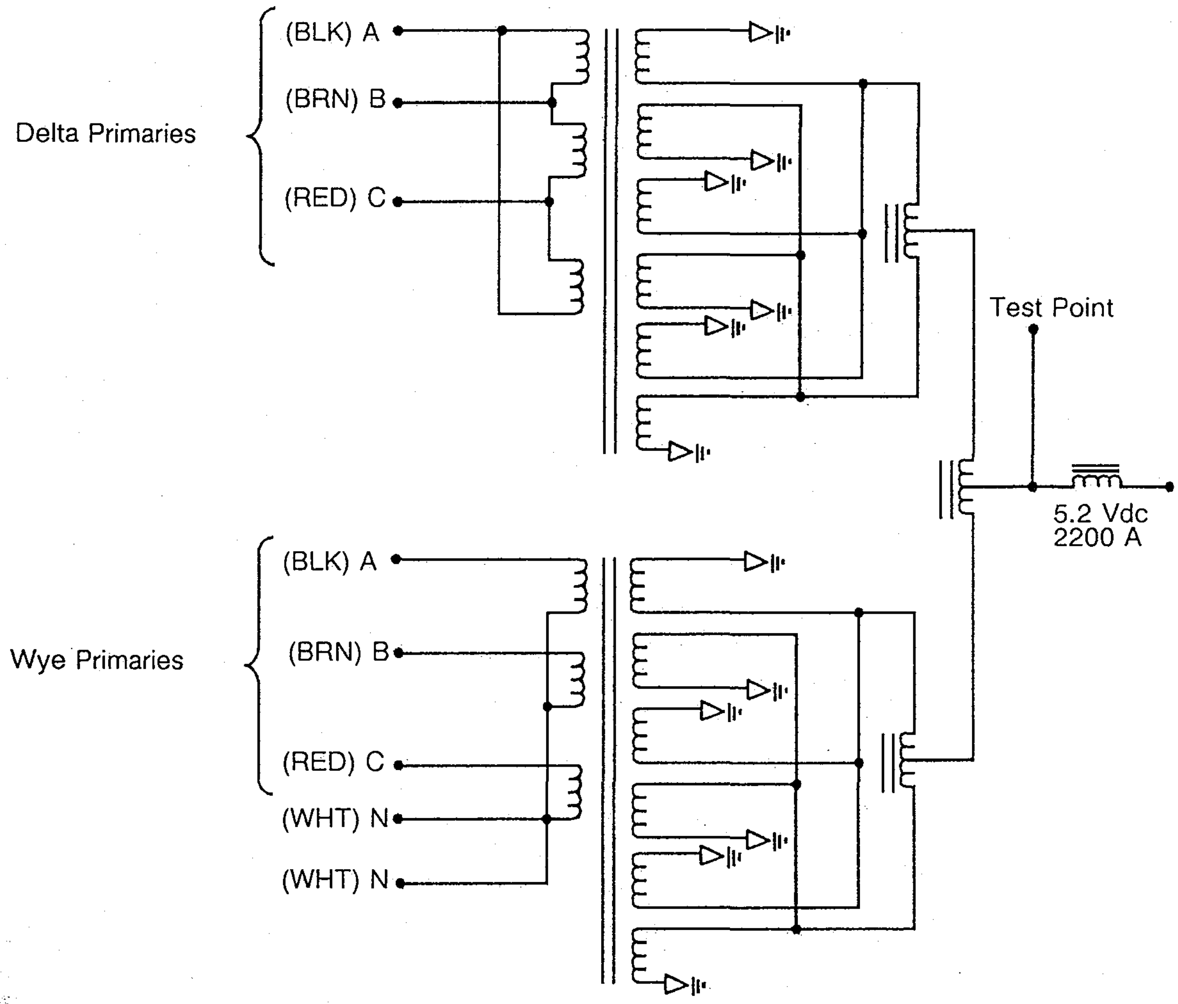


Figure 3-3. -5.2 Vdc Power Supply Electrical Schematic

circuit breaker for the power supply on the mainframe voltage adjust and circuit breaker panel also trips when a voltage surge occurs.

The transient suppressor provides protection from voltage spikes of various causes. A voltage spike can be caused by a short. If a short occurs, the current increases sharply and a voltage surge results when the cause of the short is removed. The transient suppressor absorbs the voltage spike.

The voltage value of the transient suppressor matches the breakdown voltage level of the circuitry on the module to provide the necessary protection. As stated earlier, the breakdown voltage level is approximately -7.2 Vdc. The transient suppressors are positioned with the cathode end attached to the heat sink, which is the power supply plate. The anode end attaches to the transformer.

Cooling

Dielectric fluid flows in the power supply plate through two separate circuits to remove heat from the power supplies. One large flow circuit cools the plate and removes heat from the power supply cases and diodes. Another smaller circuit has hoses attached from the power supply plate to an internal circuit in the power supply. This circuit removes the heat more directly from the internal components of the power supply.

The cooling requirements of the -2.0 Vdc power supply are 4,189 BTU per hour. The cooling requirements of the -5.2 Vdc power supply are 7,001 BTU per hour; the requirements of the -4.5 Vdc power supply are 6,059 BTU per hour.

A pump located at the Heat Exchange Unit (HEU) pumps the dielectric fluid through the CRAY Y-MP computer system at the rate of 205 gpm. The flow of dielectric fluid through the power supply plate is approximately 30 gpm. The flow through the power supplies is approximately 15 gpm. The flow through the modules is approximately 160 gpm.

The power supplies are bolted to the power supply plate using a thermal compound to aid heat transfer to the plate. The operating temperature of the power supply case is approximately 160 °F (71 °C).

Busing

Power supply buses consist of approximately 1 $\frac{1}{2}$ in. × 1 $\frac{1}{2}$ in. tin-plated, copper bars connected to the output of each power supply in the CRAY Y-MP mainframe. Each power supply provides voltage to a particular set of modules in the mainframe. As shown in Figure 3-4, the upper 16 memory modules in the computer system chassis (sections 0 and 1) have two -5.2 Vdc power supplies supplying operating voltage to the memory chips. Each of the sets of eight memory modules also has two -4.5 Vdc power supplies used for supply voltage (V_{EE}) for the 2500-gate macrocell array chips located on the modules.

A third -4.5 Vdc power supply provides voltage to the 2500-gate macrocell array chips located on the four CPU modules in the upper half of the mainframe chassis.

A -2.0 Vdc power supply provides bias voltage for the resistor layer of the 16 memory and four CPU modules located in the upper half of the computer system chassis. Layer two of each module contains the terminating resistors used to terminate all output gates. ECL circuitry requires all output gates to be terminated.

The same busing arrangement used for power supply voltages in the upper half of the mainframe chassis exists for the six power supplies in the lower half of the mainframe chassis. There are two -5.2 Vdc power supplies, a -2.0 Vdc power supply, and the three -4.5 Vdc power supplies in the lower half of the cabinet. The -4.5 Vdc power supplies provide power to the section 2 and 3 memory modules.

A -4.5 Vdc power supply located at the bottom of the chassis also provides operating voltage for the logic in the System Clock module. The module also receives -2.0 Vdc for supply voltage to the terminating resistors.

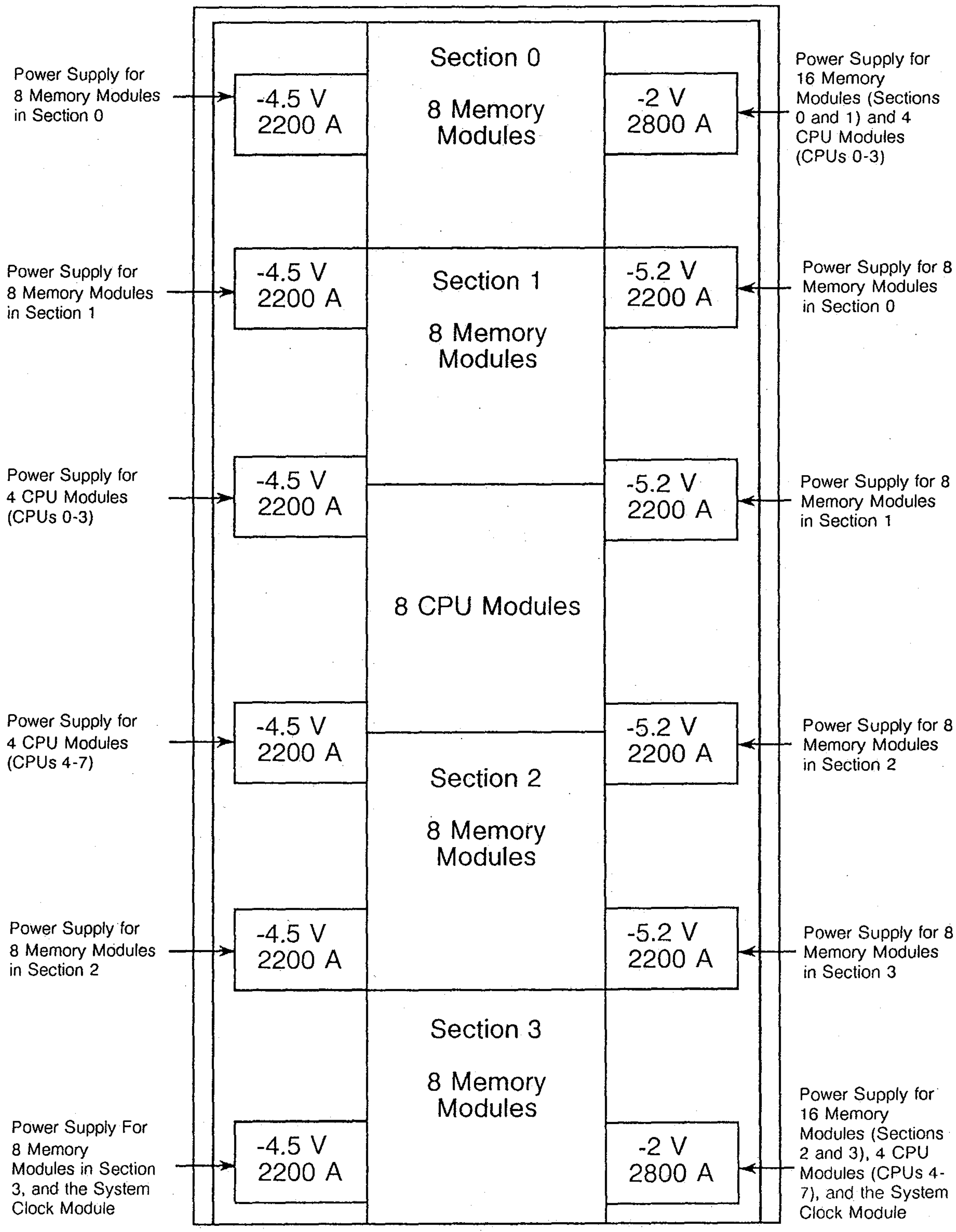


Figure 3-4. CRAY Y-MP Bused Voltages (Rear View of Mainframe)

4 - COOLING

The CRAY Y-MP Computer System uses a Freon-to-dielectric fluid heat exchange system to cool its integrated circuits. The heat generated by these circuits is as high as 500,000 BTUs per hour.

This section provides information on the operating principles involved with cooling a CRAY Y-MP Computer System and definitions of refrigeration terms. The Refrigeration Condensing Unit (RCU) and the Heat Exchange Unit (HEU) are described.

RCU PRINCIPLE OF OPERATION

The heat generated in the computer's mainframe is transferred in accordance with the second law of thermodynamics; the conversion of heat to work, is limited by the temperature at which the conversion occurs. The driving force that enables the transfer of heat is the RCU.

The RCU consists of a water-to-refrigerant heat exchanger and a compressor that acts as a gaseous pump. The RCU provides the following functions:

- Provides a high-pressure liquid to the heat exchange subassembly in the HEU and to the evaporators in the I/O Subsystem (IOS) and Solid-state Storage Device (SSD) where the heat dissipates

- Removes the superheated, low-pressure gas from the heat exchange subassembly and the evaporators

The HEU heat exchange subassembly and the evaporators dissipate heat into a refrigerant (Freon R-22) circulated through the refrigeration system by the RCU. An expansion valve on the inlet of each evaporator converts the high-pressure liquid into a low-pressure liquid. As the low-pressure liquid flows through the evaporators and absorbs heat, it is changed to a low-pressure, superheated gas.

An evaporator pressure regulator (EPR) valve located at the outlet of the evaporators controls the pressure of the gas in the evaporators. By controlling the pressure at which the refrigerant boils, the temperature of the heat exchange subassembly and each evaporator is controlled.

REFRIGERATION TERMS

This subsection defines these basic terms used in describing refrigeration systems:

- Change-of-state
- Heat transfer
- Latent heat of evaporation and condensation
- Pressure
- Saturation temperature
- Subcooled liquid
- Superheated vapor

Change-of-State

Most substances can exist as a solid, liquid, or gas, depending on the temperature and pressure they are exposed to. Heat is absorbed when a solid changes to a liquid or a liquid changes to a gas. The same amount of heat is generated when a gas changes to a liquid or when the liquid changes to a solid.

Heat Transfer

Heat flows from a high-temperature source to a low-temperature source. There are three ways of transferring heat: conduction, convection, and radiation.

Conduction is heat transfer in solids by molecular action. This method is used in a CRAY Y-MP computer system to transfer the heat from the module chips to the module cold plate and then to the heat exchange subassembly in the HEU or the evaporators in the IOS and SSD.

Convection is heat transfer by motion of a medium. Heat transfer by convection is accomplished by both liquids and gases. In a CRAY Y-MP computer system, Freon R-22 is used as the convection medium to transfer the heat from the heat exchange subassembly or the evaporators to the compressor .

Radiation is heat transfer by wave motion. When the computer equipment is running, some heat is radiated into the room.

Latent Heat of Evaporation and Condensation

The latent heat of evaporation is the amount of heat absorbed when changing a liquid to a gas. The latent heat of condensation is the amount of heat given off during the process of changing a gas to a liquid.

Pressure

The pressure a substance is exposed to alters the saturation and boiling temperatures. The greater the pressure, the higher the saturation boiling temperature.

Saturation Temperature

Saturation is the temperature and pressure at which a substance can exist simultaneously as both a liquid and a gas .

Subcooled Liquid

A subcooled liquid is a liquid that has a temperature lower than the saturation temperature corresponding to its pressure.

Superheated Vapor

Superheated vapor is a gas that has a temperature higher than its boiling or saturation temperature.

MONITORING OF RCU OPERATING CONDITIONS

The following RCU operating conditions are monitored by the RCU or the Field Engineer (FE):

- Head pressure (condensing pressure)
- Suction pressure
- Liquid (Freon R-22) subcooling
- Suction gas superheat
- High-pressure gas discharge temperature
- Compressor oil pressure
- Compressor motor temperature
- Water temperature and pressure (in and out of the condenser/receiver)

Head Pressure (condensing pressure)

For a refrigeration system to function properly and efficiently, the head pressure must be maintained within specific design limits. If the head pressure is above the design limits, the capacity and efficiency of the RCU is reduced and the following conditions occur:

- Insufficient RCU cooling capacity
- Increase in evaporator temperatures
- Excessive power consumption
- Possible over-heating of the compressors

If the head pressure is operating below the design limits, the capacity of the expansion valves is reduced because of an insufficient pressure differential (head pressure to vaporizing pressure) across the expansion valves. This reduced head pressure will result in a general unbalancing of the refrigeration system.

The head pressure should not fall outside the design limits. The selection of expansion valves for specific evaporators according to the evaporator load and the pressure differential that develops across the expansion valves ensures that head pressure remains within design limits.

The controlling parameter of the head pressure is cooling water. The following cooling water variables affect head pressure:

- Flow rate (gallons per minute - gpm)
- Inlet water temperature
- Fouling of the condenser/receiver

The buildup of minerals and other substances in the piping of the condenser/receiver (fouling) results in a restricted water flow. Fouling of the condenser/receiver is characterized by a gradual rise in head pressure and a decrease in output water temperature while the input water temperature remains constant. Once this condition occurs, the condenser/receiver must be cleaned (chemically or mechanically).

Suction Pressure

The semihermetic compressor motor relies on suction gas for self cooling. The suction pressure of the RCU must be maintained within a specified pressure range of 45 to 70 pounds per square inch gauge (psig).

If the suction pressure drops below the lower limit (45 psig), the cooling effectiveness of the gas on the motor is reduced, causing the motor and compressor cylinders to run hotter and shortening the life of the compressors. The suction pressure should be maintained as close to the upper limit (70 psig) as possible to increase the efficiency of the RCU.

By maintaining a high suction pressure, the EPR valve on the evaporator outlet can operate correctly. The EPR valve requires an approximate pressure drop of 8 psig to be able to properly regulate the evaporator pressure within a 3-ton load.

If an EPR valve is controlling the evaporator at 96 psig (57 °F or 14 °C), and the suction line pressure drop is 5 psig, the maximum suction pressure is:

96 psig - 8 psig - 5 psig = 83 psig

Controls on the RCU monitor the suction pressure. These controls are adjusted so that as the load increases, the RCU's capacity increases. This is accomplished by turning a compressor on or off, or by loading or unloading half of the compressor's cylinders. By properly adjusting the controls, the operating range can be maintained between 12 and 44 1/2 tons.

Liquid Subcooling (Freon R-22)

A liquid is subcooled if it is below its saturation temperature. Liquid subcooling is referred to as the temperature difference between the actual measured liquid temperature and its corresponding saturation temperature base, based upon its condensing pressure (refer to Table 4-1).

For example, if the condensing pressure is 210 psig, its saturation temperature is 105 °F (41 °C). If the liquid-line temperature is measured at 85 °F (29 °C), the subcooling temperature is: 105 - 85 = 20 °F (12 °C)

Subcooling of the liquid refrigerant occurs in the condenser/receiver tank. The coldest water enters the bottom 1/3 of the tank and cools the condensed refrigerant below its saturation temperature. The degree of subcooling is dependent upon the water temperature and the amount of refrigerant in the condenser/receiver. If more refrigerant is added when the system is fully charged (no bubbles in liquid-line sight glass), the refrigerant is forced to collect in the condenser/receiver as a liquid. As refrigerant is added, the liquid in the tank increases, allowing it to remain in the tank and subcool further. If too much refrigerant is added, it reduces the effective heat transfer surface and adversely affects the performance of the RCU. Typical refrigerant subcooling is between 15 °F (8 °C) and 20 °F (11 °C).

Suction Gas Superheat

A gas is superheated if it is above its saturation temperature. Suction gas superheat is the temperature difference between the measured suction line temperature and the corresponding saturation temperature based upon its suction pressure (refer to Table 4-1).

If the suction pressure is 65 psig, its corresponding saturation temperature is 37 °F (3 °C) (refer to Table 4-1). If the measured suction line temperature is 57 °F (14 °C), then the suction gas superheat is: 57 - 37 = 20 °F (11 °C)

The temperature of the suction gas returning to the compressor is important because it prevents liquid refrigerant from entering the compressors and it ensures that the compressor motors are adequately cooled.

CAUTION

Hazard to equipment. Insure that a minimum superheat temperature of15 °F (18 °C) is maintained at all times to prevent liquid refrigerant from entering the compressors (slugging). Slugging can cause damage such as broken discharge valve plates and broken connecting rods. Liquid refrigerant canalso mix with oil, causing poor lubrication and subsequent bearing wear.

A maximum suction gas temperature of 65 °F (18 °C) ensures that the compressor motors are continuously cooled by the suction gas. If the suction gas temperature rises above 65 °F (18 °C), the motors and compression heat raises the gas temperature high enough to cause the oil on the cylinder walls to vaporize and an oil breakdown to occur at the discharge valve ports. Suction gas over-heating results in severe compressor wear and eventual compressor failure.

The superheat temperature of the suction gas is dependent on the combined superheat setting of each evaporator. If the superheat temperature is not within a specified range (refer to "Evaporator Adjustments" in Section 5 for superheat settings), the superheat setting of each evaporator must be readjusted. An increase in the suction gas temperature is reflected by an increase in the discharge gas temperature

Table 4-1. Refrigerant Temperature-pressure Chart

Temper -ature F°	Pressure†					Temper -ature F°	Pressure				
	Freon R-12	Freon R-22	Freon R-500	Freon R-502	Freon R-717		Freon R-12	Freon R-22	Freon R-500	Freon R-502	Freon R-717
-60	*19.0*	*12.0*	*17.0*	*7.2*	*18.6*	27	26.1	51.2	33.2	61.5	41.4
-55	*17.3*	*9.2*	*15.0*	*3.8*	*16.6*	28	26.9	52.4	34.2	62.8	42.6
-50	*15.4*	*6.2*	*12.8*	*0.2*	*14.3*	29	27.7	53.6	35.1	64.2	43.8
-45	*13.3*	*2.7*	*10.4*	1.9	*11.7*	30	28.4	54.9	36.0	65.6	45.0
-40	*11.0*	0.5	*7.6*	4.1	*8.7*	31	29.2	56.2	36.9	67.0	46.3
-35	*8.4*	2.6	*4.6*	6.5	*5.4*	32	30.1	57.5	37.9	68.4	47.6
-30	*5.5*	4.9	*1.2*	9.2	*1.6*	33	30.9	58.8	38.9	69.9	48.9
-25	2.3	7.4	1.2	12.1	1.3	34	31.7	60.1	39.9	71.3	50.2
-20	0.6	10.1	3.2	15.3	3.6	35	32.6	61.5	40.9	72.8	51.6
-18	1.3	11.3	4.1	16.7	4.6	36	33.4	62.8	41.9	74.3	52.9
-16	2.0	12.5	5.0	18.1	5.6	37	34.3	64.2	42.9	75.8	54.3
-14	2.8	13.8	5.9	19.5	6.7	38	35.2	65.6	43.9	77.4	55.7
-12	3.6	15.1	6.8	21.0	7.9	39	36.1	67.1	45.0	79.0	57.2
-10	4.5	16.5	7.8	22.6	9.0	40	37.0	68.5	46.1	80.5	58.6
- 8	5.4	17.9	8.8	24.2	10.3	41	37.9	70.0	47.1	82.1	60.1
- 6	6.3	19.3	9.9	25.8	11.6	42	38.8	71.4	48.2	83.8	61.6
- 4	7.2	20.8	11.0	27.5	12.9	43	39.8	73.0	49.4	85.4	63.1
- 2	8.2	22.4	12.1	29.3	14.3	44	40.7	74.5	50.5	87.0	64.7
0	9.2	24.0	13.3	31.1	15.7	45	41.7	76.0	51.6	88.7	66.3
1	9.7	24.8	13.9	32.0	16.5	46	42.6	77.6	52.8	90.4	67.9
2	10.2	25.6	14.5	32.9	17.2	47	43.6	79.2	54.0	92.1	69.5
3	10.7	26.4	15.1	33.9	18.0	48	44.6	80.8	55.1	93.9	71.1
4	11.2	27.3	15.7	34.9	18.8	49	45.7	82.4	56.3	95.6	72.8
5	11.8	28.2	16.4	35.8	19.6	50	46.7	84.0	57.6	97.4	74.5
6	12.3	29.1	17.0	36.8	20.4	55	52.0	92.6	63.9	106.6	83.4
7	12.9	30.0	17.7	37.9	21.2	60	57.7	101.6	70.6	116.4	92.9
8	13.5	30.9	18.4	38.9	22.1	65	63.8	111.2	77.8	126.7	103.1
9	14.0	31.8	19.0	39.9	22.9	70	70.2	121.4	85.4	137.6	114.1
10	14.6	32.8	19.7	41.0	23.8	75	77.0	132.2	93.5	149.1	125.8
11	15.2	33.7	20.4	42.1	24.7	80	84.2	143.6	102.0	161.2	138.3
12	15.8	34.7	21.2	43.2	25.6	85	91.8	155.7	111.0	174.0	151.7
13	16.4	35.7	21.9	44.3	26.5	90	99.8	168.4	120.6	187.4	165.9
14	17.1	36.7	22.6	45.4	27.5	95	108.2	181.8	130.6	201.4	181.1
15	17.7	37.7	23.4	46.5	28.4	100	117.2	195.9	141.2	216.2	197.2
16	18.4	38.7	24.1	47.7	29.4	105	126.6	210.8	152.4	231.7	214.2
17	19.0	39.8	24.9	48.8	30.4	110	136.4	226.4	164.1	247.9	232.3
18	19.7	40.8	25.7	50.0	31.4	115	146.8	242.7	176.5	264.9	251.5
19	20.4	41.9	26.5	51.2	32.5	120	157.6	259.9	189.4	282.7	271.7
20	21.0	43.0	27.3	52.4	33.5	125	169.1	277.9	203.0	301.4	293.1
21	21.7	44.1	28.1	53.7	34.6	130	181.0	296.8	217.2	320.8	---
22	22.4	45.3	28.9	54.9	35.7	135	193.5	316.6	232.1	341.2	---
23	23.2	46.4	29.8	56.2	36.8	140	206.6	337.2	247.7	362.6	---
24	23.9	47.6	30.6	57.5	37.9	145	220.3	358.9	264.0	385.0	---
25	24.6	48.8	31.5	58.8	39.0	150	234.6	381.5	281.1	408.4	---
26	25.4	49.9	32.4	60.1	40.2	155	249.5	405.1	298.9	432.9	---

† Italic figures are inches of mercury and all other figures are pounds per square inch gauge

Discharge Gas Temperature

A discharge gas temperature is the temperature at which the vapor is discharged from the compressor. Measure the temperature approximately 6 in. (15 cm) from the outlet of each compressor's discharge service valve. Varying discharge temperatures are good indicators of the RCU's operating condition.

A discharge temperature of 225 °F (107 °C) or less indicates that the compressors are operating within their design constraints; a discharge temperature of 250 °F (121 °C) to 274 °F (134 °C) indicates abnormal conditions requiring immediate corrective action; and a discharge temperature of 275 °F (135 °C) or more indicates imminent condenser failure.

A high discharge gas temperature can result from one or more of the following conditions:

- Broken compressor discharge or suction reed valves
- Low operating suction pressure
- High suction line superheat
- High condensing pressure
- Low input voltage to compressors
- Short cycling of compressor unloaders
- Improper lubrication

Compressor Oil Pressure

Oil pressure in the compressor is monitored continuously by the OIL PRESSURE control unit on the RCU. If the oil pressure differential falls below 9 psig for more than 2 minutes, the OIL PRESSURE control unit shuts the compressor off. The reset button on the OIL PRESSURE control unit must be pushed before the compressor can be reactivated.

Compressor Motor Temperature

Compressor motor temperature is monitored by a thermostat located within the compressor motor. Temperature fault limits are set at the time of manufacture of the motor. The RCU powers down immediately in the event of a high temperature condition. The most common cause of a high temperature condition is the loss of one of the three electrical phases of power to the compressor motor. More extreme causes range from motor bearing wear to shorted windings in the compressor motor.

Water temperature and pressure (in and out of the condenser/receiver)

The inlet condensing water temperature should be between 40 °F (4 °C) and 70 °F (32 °C). The outlet should be from 8 °F to 12 °F (4 °C to 7 °C) higher in temperature than the inlet water temperature.

Not all units have a gauge to measure the pressure of the inlet and outlet condensing water. A normal pressure differential is between 5 and 20 psig.

MAINFRAME AND AUXILIARY RCU OPERATION

The amount of cooling required for a CRAY Y-MP Computer System determines the refrigeration needs for each site. Two RCUs are available to provide the needed cooling. The RCU-1 cools all CRAY Y-MP mainframe systems. The RCU-2 cools the Solid-state Storage Devices (SSD) and I/O Subsystem chassis (IOS).

This section describes the operation of the CRAY Y-MP computer system RCU-1 and RCU-2, and also provides detailed description of the RCU-1 and RCU-2 components.

RCU Components

This subsection describes the following RCU-1 and RCU-2 components (refer to Figure 4-1):

- Refrigerant
- Condenser/receiver
- Water regulating valve
- Liquid-line sight glass
- Solenoid valve
- Liquid-line strainer
- Expansion valve
- Evaporator
- Evaporator pressure regulating (EPR) valve
- Suction accumulator
- Compressor service valve

Refrigerant

The RCU-1 and RCU-2 use Freon (R-22). It is a clear liquid when below its boiling point of -41.4 °F (-46 °C) at atmospheric pressure. It is considered nontoxic, nonirritating, nonexplosive, and nonflammable. R-22 has a higher saturation pressure and a larger latent heat of evaporation than some other refrigerants.

Condenser/Receiver

The high-pressure refrigerant arrives at the condenser/receiver from the compressor. The refrigerant has a higher saturation temperature than the water-cooled condenser and, therefore condenses upon arrival. As the refrigerant condenses to a liquid, it falls to the bottom of the tank (receiver) and is subcooled by the continual flow of water through the tank.

Water Regulating Valve

The water regulating valve (refer to Figure 4-2) controls the flow of chilled water that enters the RCU. By adjusting the screw on top of the valve a course adjustment is obtained. A fine adjustment is maintained by the head pressure.

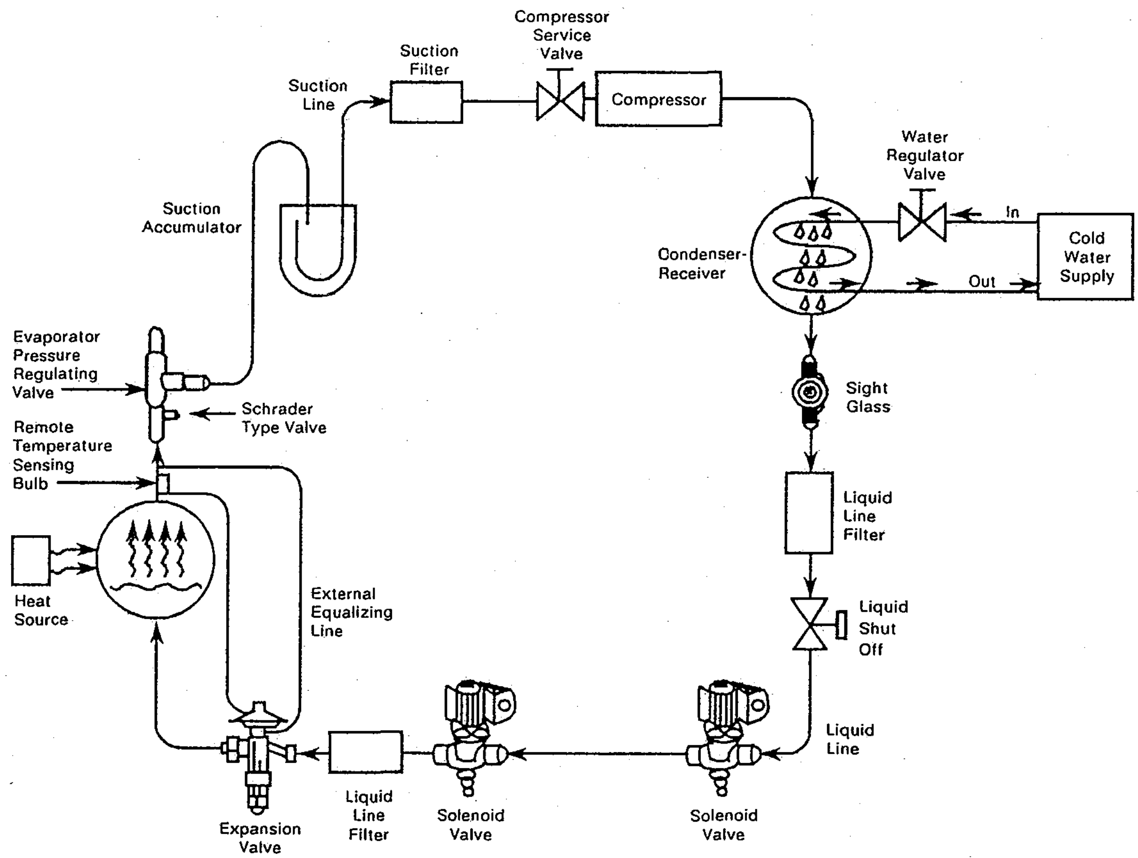


Figure 4-1. Common Refrigeration System Components

The valve continually monitors the head pressure by means of a refrigeration pressure line common to the pressure gauge on the unit. As the head pressure increases, the valve opens allowing more water to enter the condenser and remove the refrigerant heat. This process lowers the condensing pressure. If the head pressure decreases, the valve closes, decreasing the flow of chilled water and raising the condensing temperature.

Liquid-line Sight Glass

The liquid-line sight glass (refer to Figure 4-3) allows monitoring of the refrigerant flow. Bubbles or foam in the sight glass indicates a shortage of refrigerant or an obstruction in the liquid line.

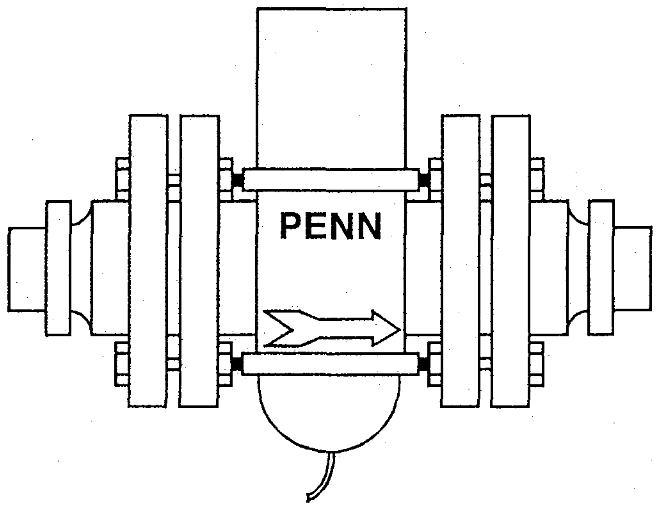


Figure 4-2. Water Regulating Valve

The liquid-line sight glass also contains a system moisture indicator. The colored dot in the center of the sight glass is dark green when the system contains an acceptable moisture level. If moisture contaminates the refrigerant, the dot changes to light green and eventually to yellow when an unacceptable amount of moisture exists. If the system has too much moisture, check for leaks and replace the liquid-line filter dryer.

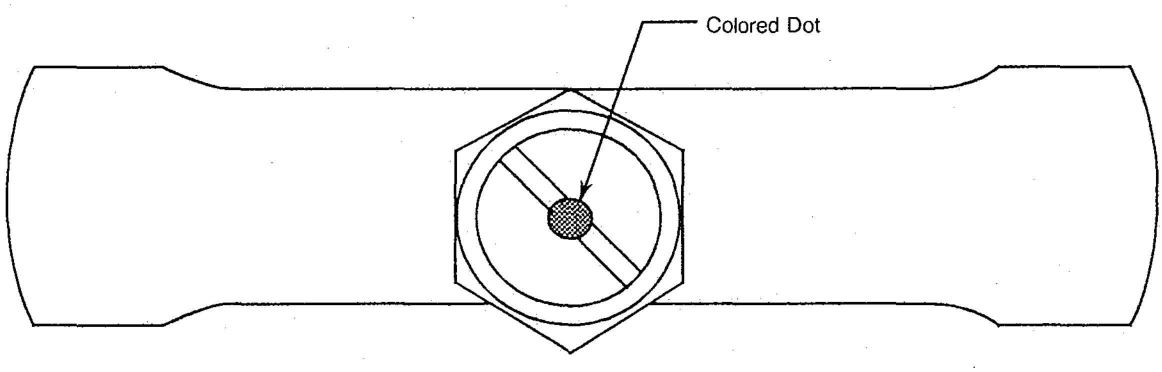


Figure 4-3. Liquid Line Sight Glass

Solenoid Valve

The solenoid valve (refer to Figure 4-4) controls the flow of refrigerant through the liquid and hot gas lines. It stops the flow of refrigerant into the evaporator when the RCU is powered off. The valve consists of a body and an iron core plunger seated in the valve orifice. The valve is controlled by an electrical solenoid coil and is normally closed. When the solenoid is energized, the plunger lifts and opens the valve.

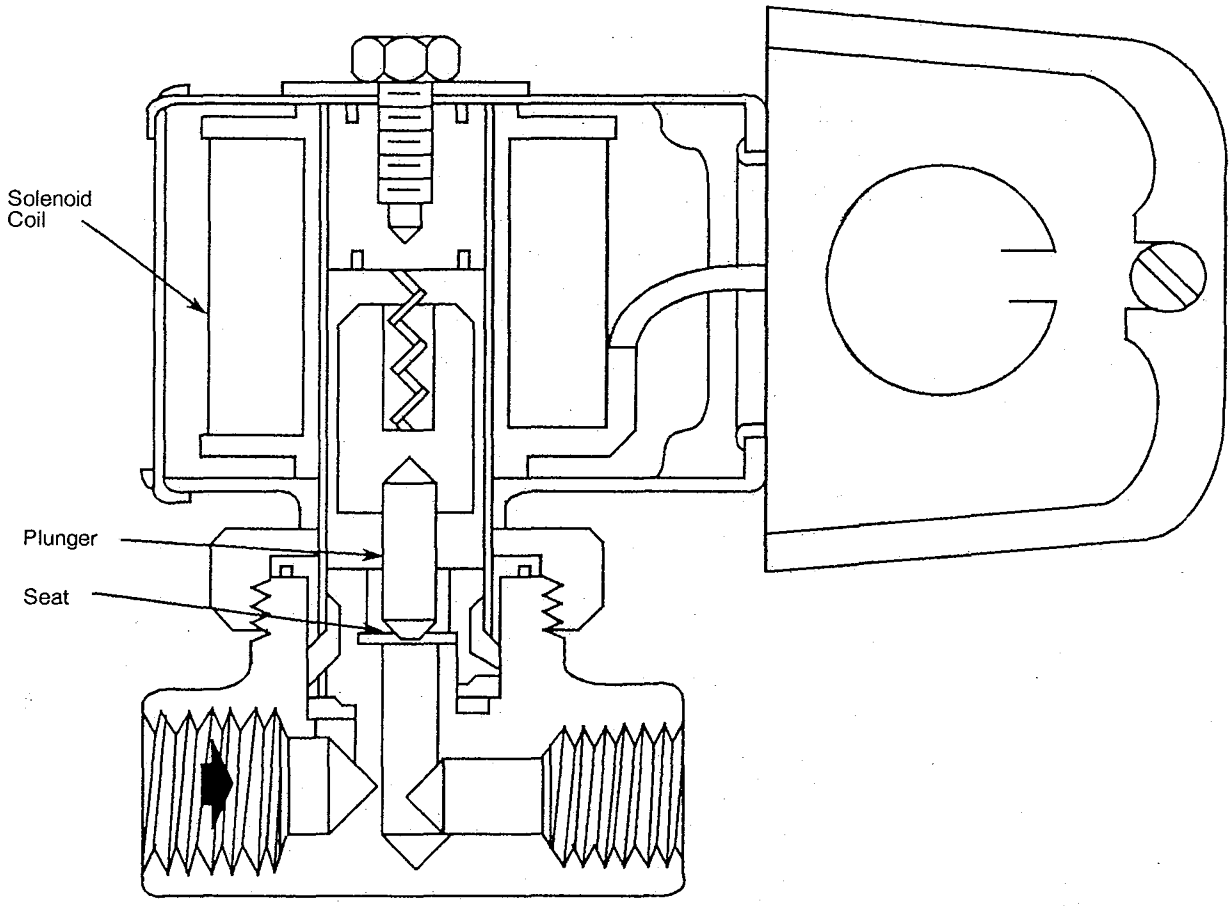


Figure 4-4. Solenoid Valve

Expansion Valve

The expansion valves (refer to Figure 4-5) control the amount of refrigerant flow through the evaporator. The expansion valve contains a small orifice through which liquid refrigerant flows. Because of the pressure drop that occurs across the orifice some of the liquid changes to a vapor.

Each evaporator in the system has an expansion valve. The expansion valve is externally controlled by a remote temperature sensing bulb that monitors the temperature of the evaporator.

Liquid refrigerant (R-22) enters the valve from the condenser/receiver and flows between the needle and valve seat, exiting to the evaporator as a vaporous liquid. In the evaporator, the refrigerant is exposed to a lower vapor pressure where it further vaporizes and absorbs heat.

The valve diaphragm is controlled by three different pressures: remote temperature sensing bulb pressure, evaporation pressure, and the adjustable spring pressure. The valve needle is located on the end of a push rod, which is connected to the diaphragm. Each expansion valve has two push rods controlling the needle.

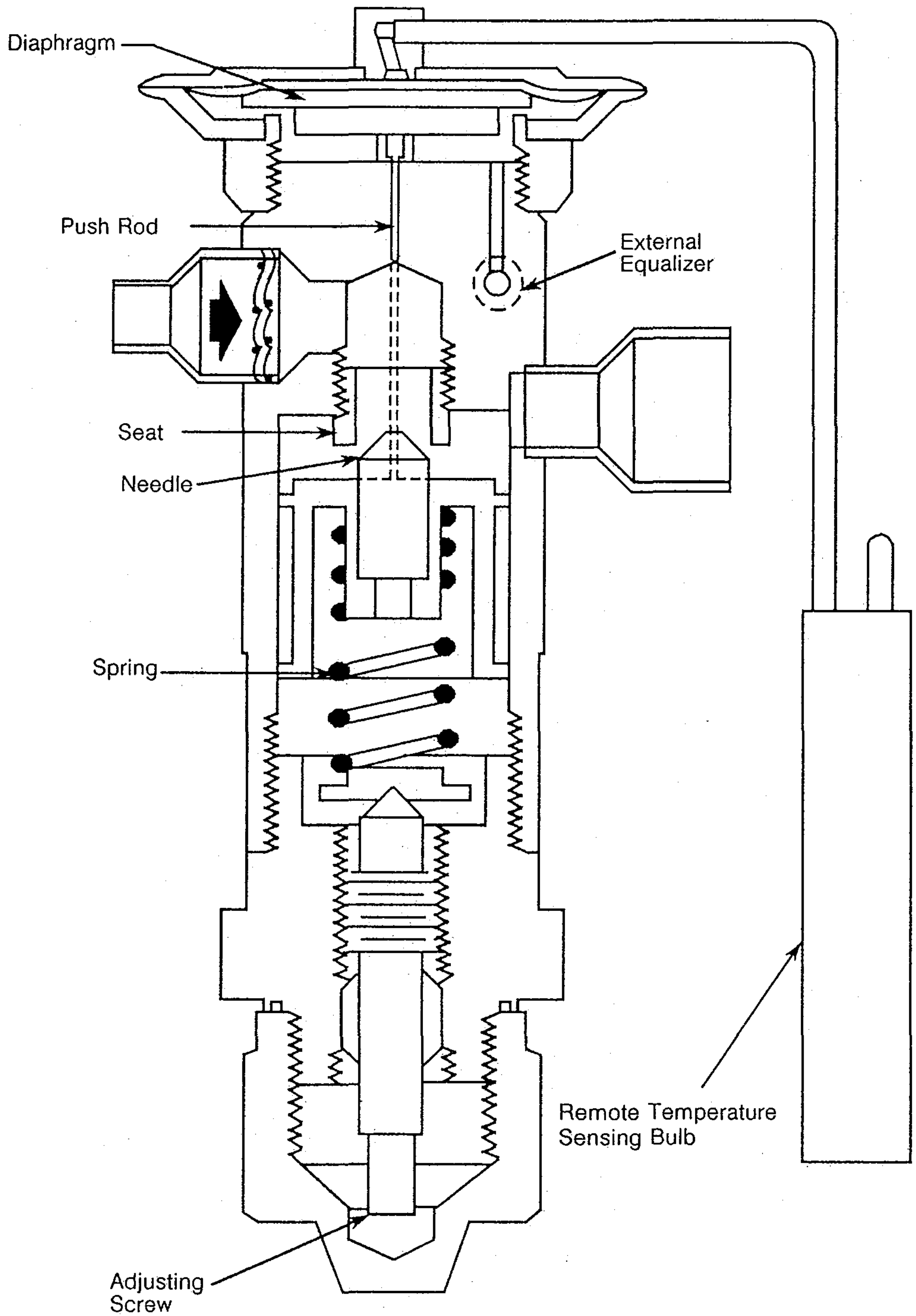


Figure 4-5. Expansion Valve

The remote temperature sensing bulb and connecting tube contain the same R-22 refrigerant as the refrigeration system. The bulb is located near the end of the evaporator. The temperature of the evaporator affects the pressure of the refrigerant in the sensing bulb.

The sensing bulb pressure is equalized by an external equalizing line. This line is connected to the refrigeration system piping at the outlet of the evaporator. The line equalizes the pressure difference that occurs between the inlet and outlet of the evaporator, thus balancing the expansion valve diaphragm position, independent of the pressure drop through the evaporator.

By monitoring the remote temperature sensing bulb pressure and the evaporator pressure change, the expansion valve automatically adjusts to assure a constant refrigerant vapor temperature (superheat temperature).

By adjusting the spring pressure of the expansion valve, an operator is able to control the amount of liquid refrigerant flowing through the expansion valve. The amount of liquid refrigerant entering the evaporator also controls the refrigerant superheat.

Evaporator

A plate-to-plate, cross-counter flow heat exchange subassembly in the HEU is the evaporator for the CRAY Y-MP mainframe refrigeration system. The cold-bar columns and the power supply cold plates are the evaporators in the IOS and SSD refrigeration systems. Heat generated by the integrated circuits or power supplies is transferred to the evaporators.

The evaporator pressure is lower than the liquid-line pressure, causing the liquid refrigerant to vaporize and absorb heat from the heat exchange subassembly and the cold bars. "Evaporator Adjustments", in Section 5 of this manual describes how to set the evaporator temperature.

Evaporator Pressure Regulating (EPR) Valve

The Evaporator Pressure Regulating (EPR) valve (refer to Figure 4-6) maintains a desired evaporator pressure and temperature during changing heat load conditions. The valve is located on the outlet of the evaporator.

The vaporized refrigerant enters the EPR valve through the inlet port, flows between the valve seat and the seat disc, and exits the valve through the outlet port. The outlet port is connected to the suction line.

The EPR valve automatically responds to variations in the inlet pressure. If the heat load on the evaporator decreases and the evaporator pressure falls toward the preset minimum regulator pressure, the spring of the EPR valve forces the seat closed. This action decreases the vapor flow through the suction line, therefore maintaining the pressure.

If the heat load increases so that evaporator pressure increases above its maximum setting, the evaporator pressure forces the seat to an open position. This action allows more refrigerant vapor to flow through the suction line and lowers the pressure closer to the desired setting.

The adjustable spring regulates the evaporator temperature by controlling the evaporator pressure.

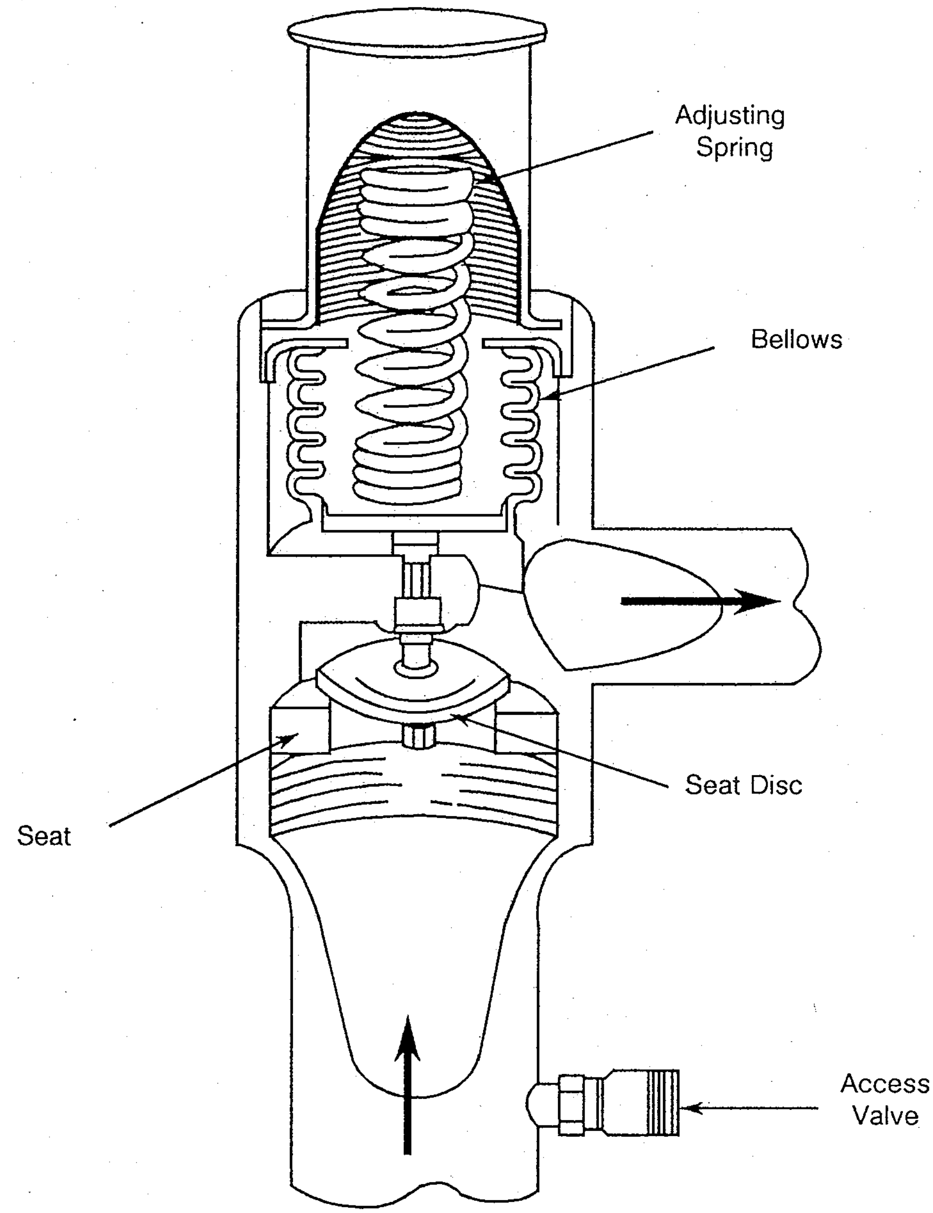


Figure 4-6. Evaporator Pressure Regulating Valve

The Schrader type valve (refer to Figure 4-7) is mounted inside the access valve on the EPR valve and allows quick access to the refrigeration system for performing maintenance or system monitoring. If the valve is seated and closed, refrigerant is not allowed to pass. When the manifold gauge is connected to the valve, the valve stem is depressed and the pressure of the refrigerant can be read on the gauge.

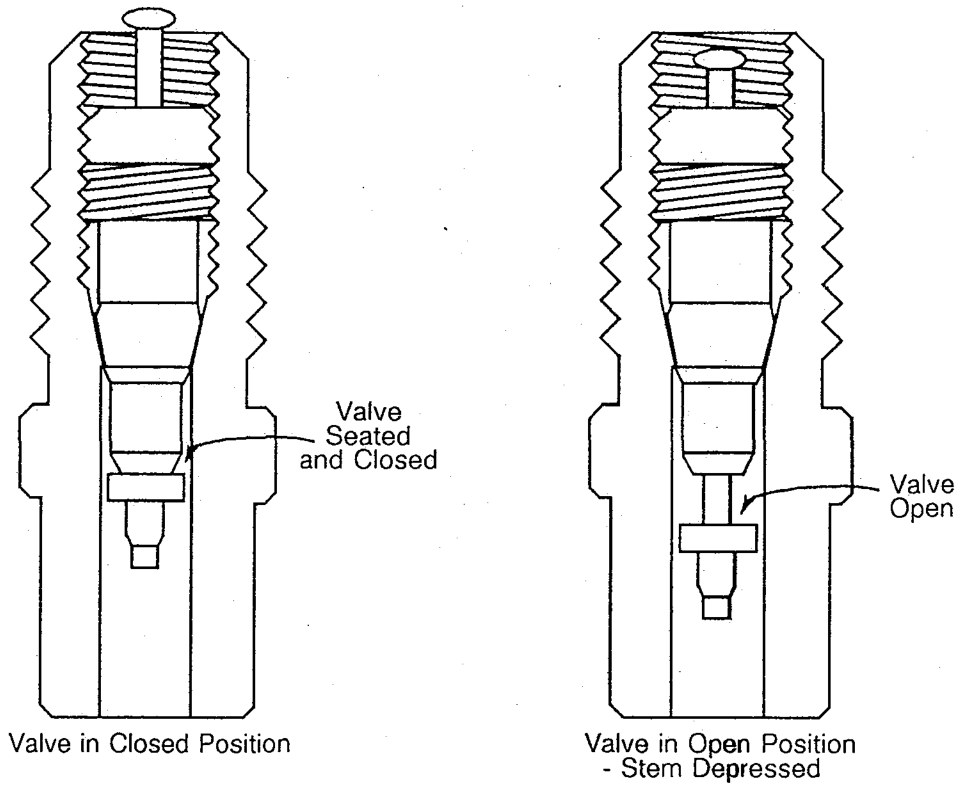


Figure 4-7. Schrader Type Valve

Suction Accumulator

The suction accumulator (refer to Figure 4-8) prevents liquid refrigerant from entering the compressor. If liquid refrigerant enters the compressor, slugging or oil loss occurs and the compressor could be damaged.

The accumulator is positioned vertically in the suction line between the evaporator and compressor. The refrigerant gas enters the accumulator from the top. Any liquid refrigerant mixed with the gas settles to the bottom of the accumulator and the gas follows the suction line to the compressor. The higher temperature gas causes the liquid refrigerant to boil and vaporize; the resulting gas then flows to the compressor.

Compressor Service Valve

There are two compressor service valves in the RCU (refer to Figure 4-9): one discharge service valve and one suction service valve. The purpose of the valves is to isolate the compressor from the refrigeration system when maintenance is required.

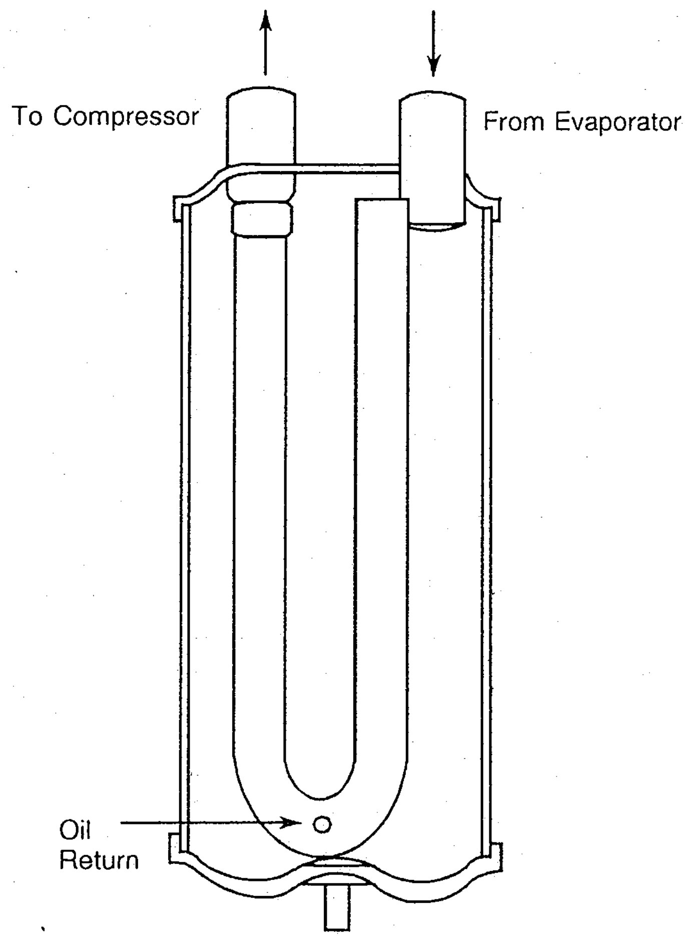


Figure 4-8. Suction Accumulator

When the valve stem is fully backseated, the gauge port is closed off from pressure. One full turn of the valve stem allows pressure to flow through the gauge port. When the valve stem is fully frontseated, pressure cannot enter the compressor.

CAUTION

Hazard to compressor service valve. Loosen the packing nut for compressor service valve before turning the valve stem. Failure todo so will damage the valve.

Once the valve stem is positioned, the packing nut must be tightened and the cap replaced.

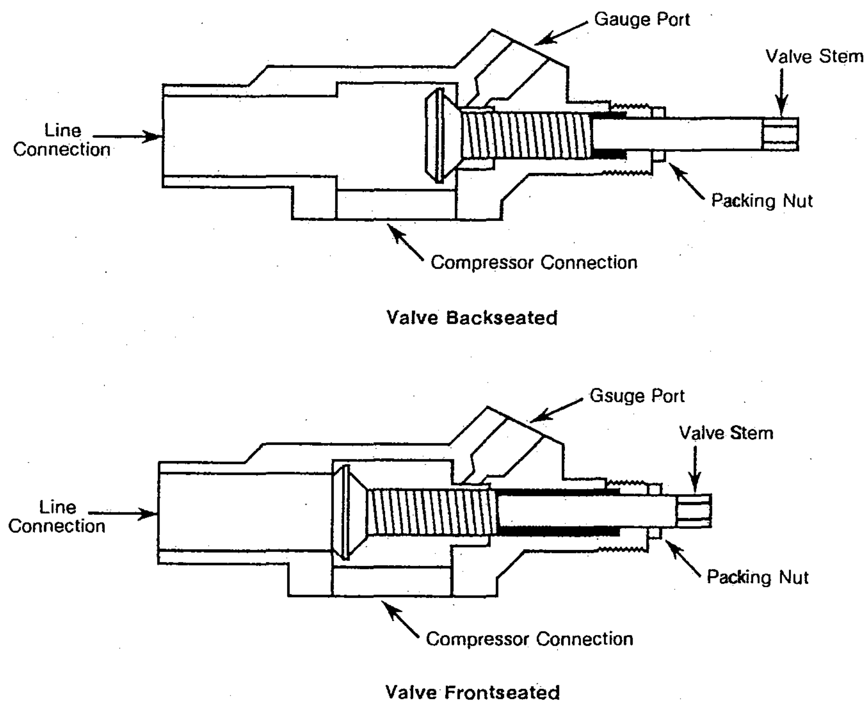


Figure 4-9. Compressor Service Valve

MAINFRAME RCU

Figure 4-10 shows the component locations for the mainframe RCU (RCU-1). The following components are specific to the RCU-1 (refer to Figure 4-11) and are described in this subsection:

- Suction filter
- Compressor assembly
- Control panel
- Electrical wiring
- Liquid-line filter dryer

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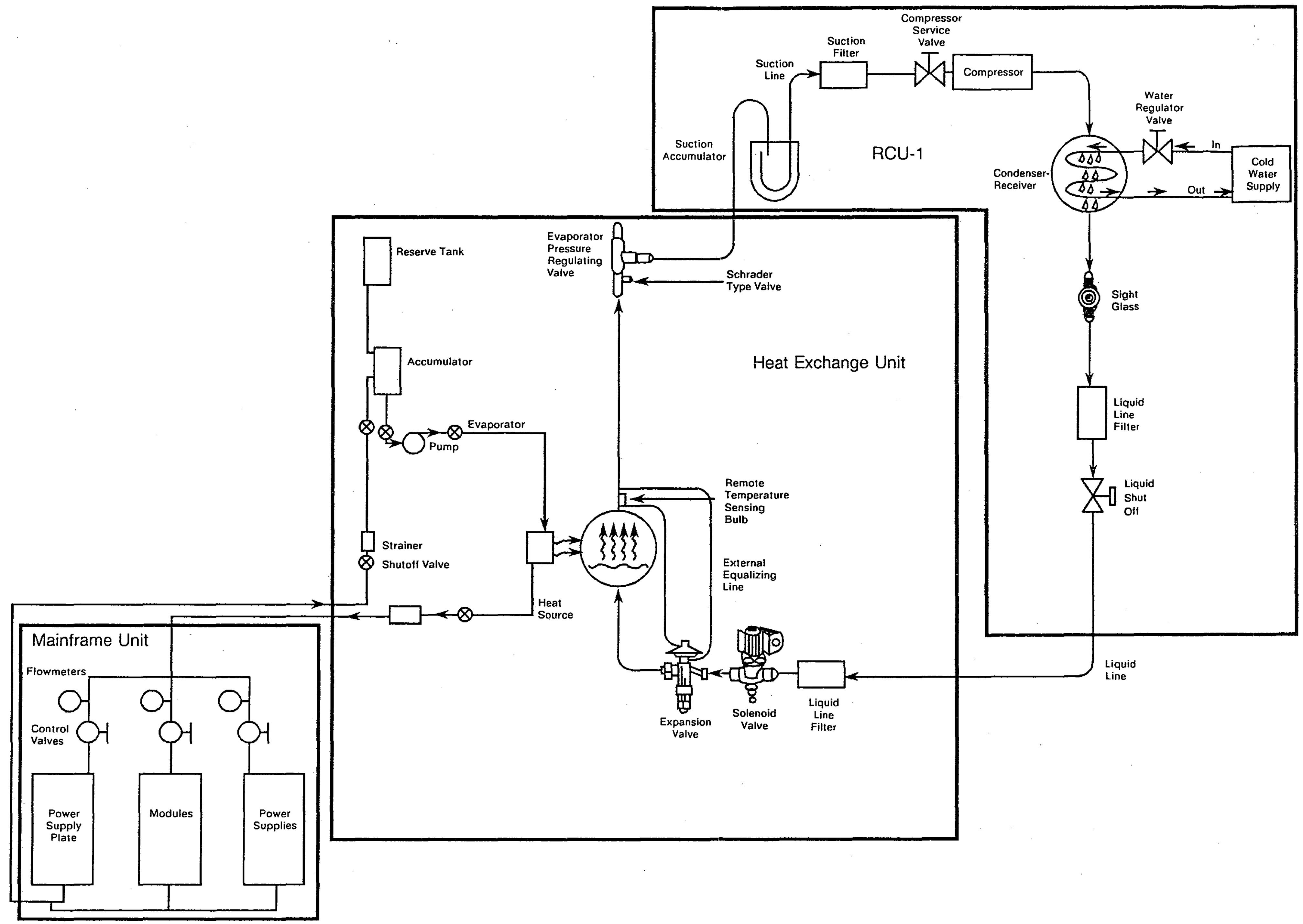

Figure 4-10. CRAY Y-MP Refrigeration System

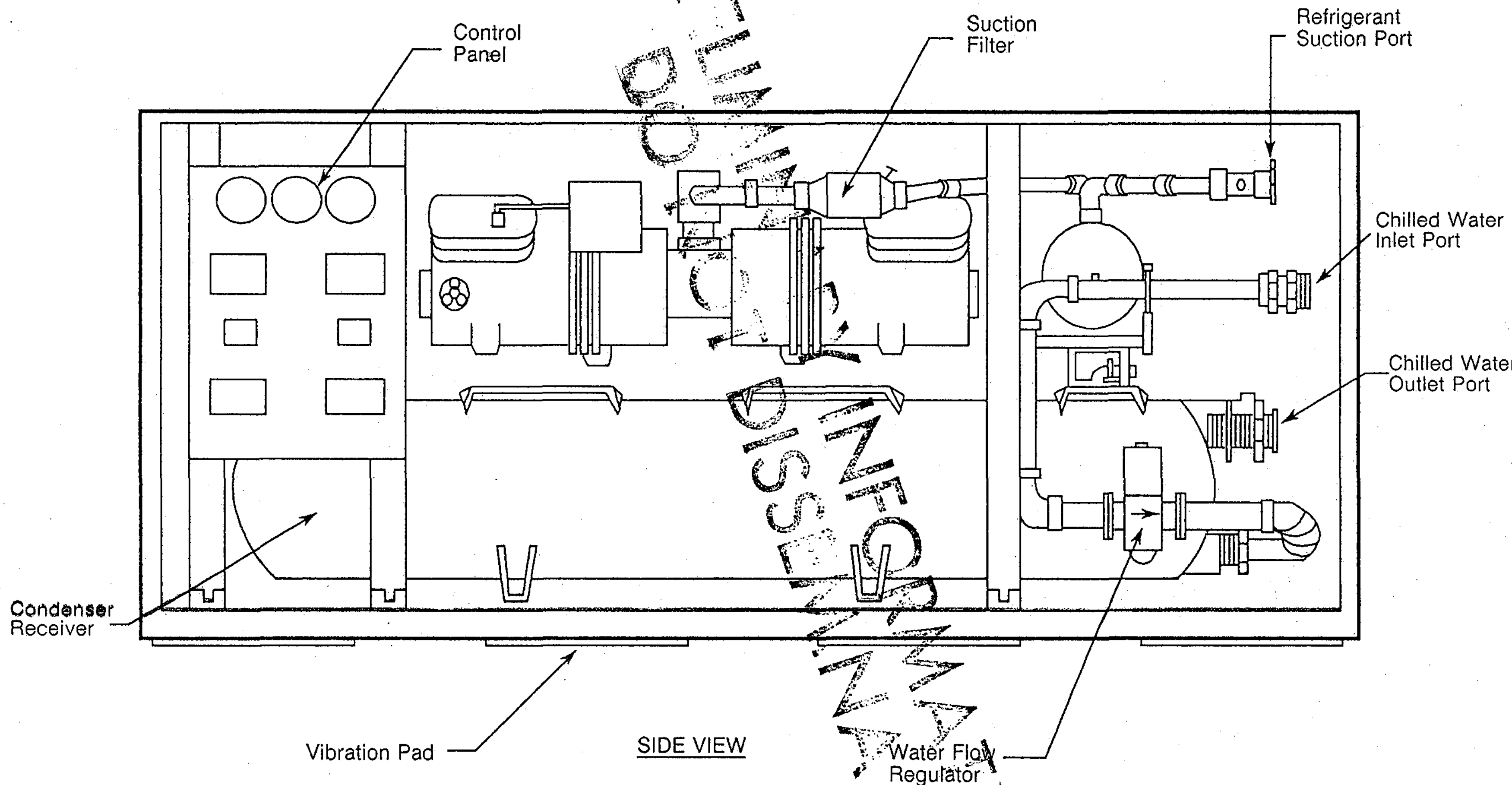

Figure 4-11. RCU-1 Component Locations (Page 1 of 2)

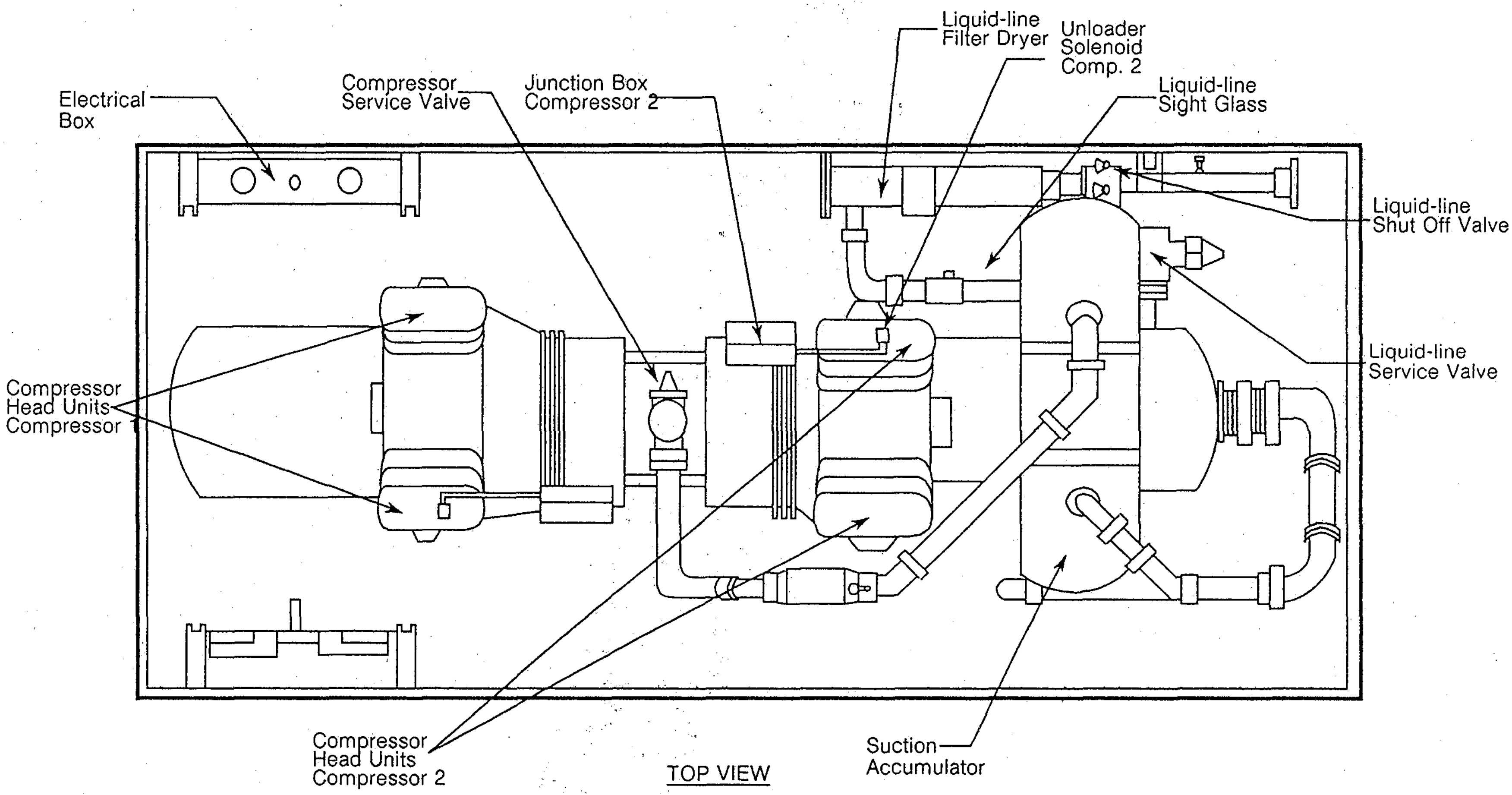

Figure 4-11. RCU-1Component Locations (Page 2 of 2)

Suction Filter

A suction filter is installed in the RCU-1 to protect the compressor from contamination such as dirt or metal shavings left in the system at the time of installation. The filter is permanently installed and has a sealed, nonreplaceable inner cartridge.

If the filter becomes clogged, it is equipped with a relief device that opens to permit suction vapor to bypass the clogged area (refer to Figure 4-12). The dirt trapped in the filter is not released when the valve opens; it remains embedded in the wool fibers of the cartridge. If additional dirt enters the suction filter, it is caught in the back section of the filter cartridge due to the direction change of the vapor flow.

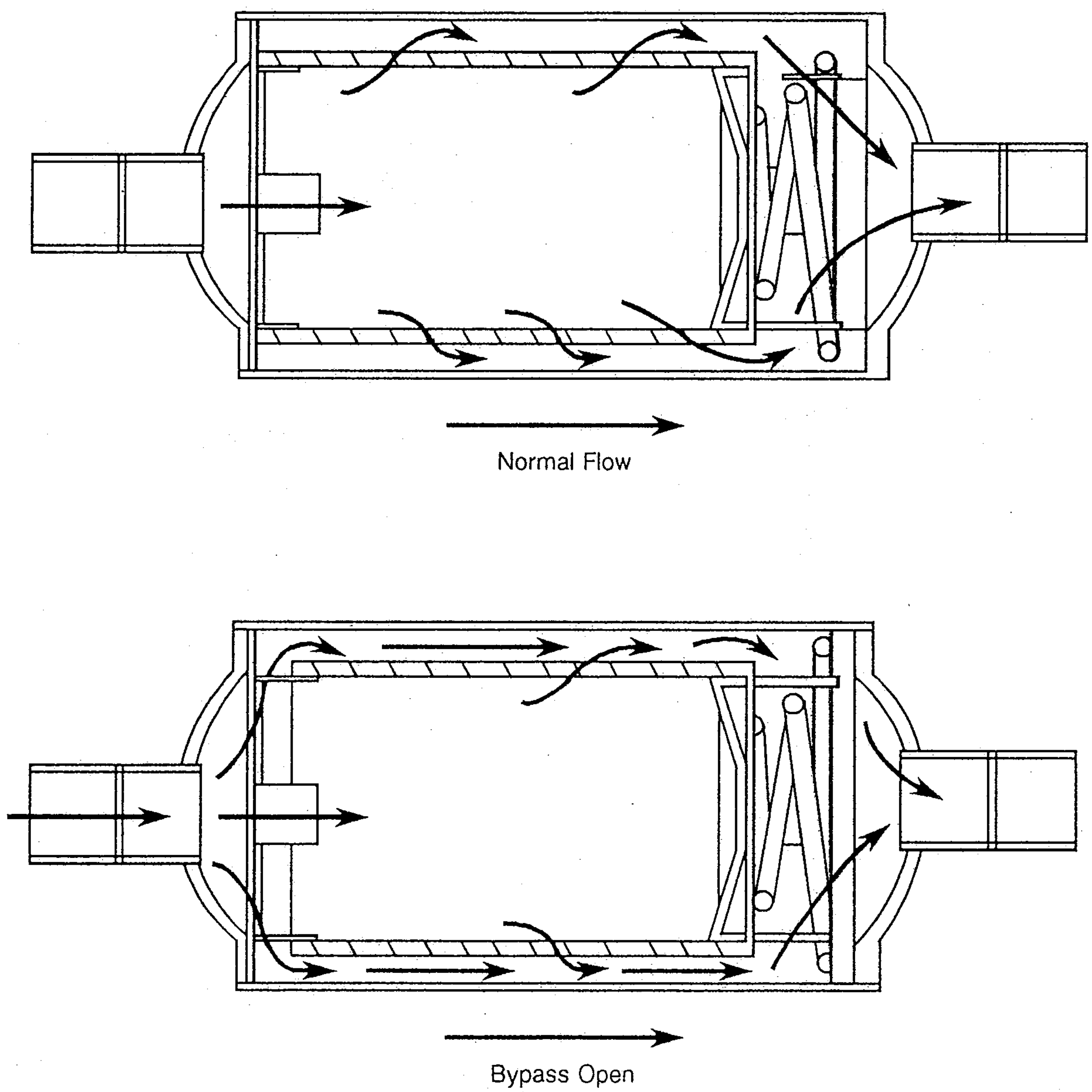

Figure 4-12. Suction Filter Flow

Compressor Assembly

The RCU-1 uses a tandem compressor assembly. Both compressors in the assembly operate on the same suction line and discharge compressed gas to the same condenser/receiver.

The compressor motor's and compressor's working parts are sealed within a common enclosure. The compressor pistons have a reciprocating motion, similar to an automotive engine. The piston cylinder is equipped with suction and discharge reed valves. Each compressor has two sections containing two pistons each plus a separate compressor head unit for each pair of pistons.

The compressor head unit (refer to Figure 4-13) is divided into two sections and located in the top part of the compressor. The refrigerant gas enters the compressor through the suction chamber of the head unit and discharges through the discharge reed valves that lead to the high-pressure side of the compressor head.

When the piston is in a downward stroke, the suction reed valves open, allowing the piston to draw in the refrigerant gas from the suction chamber of the head unit. On an upward stroke, the suction reed valves close and the gas is compressed. As the gas compresses, the pressure increases and causes the discharge valves to open. The compressed gas leaves the cylinder and enters the high-pressure side of the compressor head.

Unloader Solenoid Valve

The head for one pair of pistons has an unloader solenoid valve mounted on the suction valve inlet port. The unloader solenoid valve controls the refrigerant gas entering the suction chamber of the head unit.

When the solenoid is de-energized (refer to Figure 4-14), the needle valve is seated on the lower port. The plunger chamber is then exposed to suction pressure through the suction pressure port. Because the bottom of the plunger is open to the suction chamber of the compressor head unit, the gas pressure across the plunger is equalized, allowing the spring to hold the plunger in the open position. Suction gas then enters the suction chamber of the head unit and the unloaded piston cylinders.

When the solenoid is energized, it pulls the needle valve upward and the plunger chamber is exposed to discharge pressure from the discharge pressure port. The differential between the discharge and suction pressure forces the plunger down, sealing the suction port. This prevents the entrance of suction gas into the suction chamber and unloaded piston cylinders.

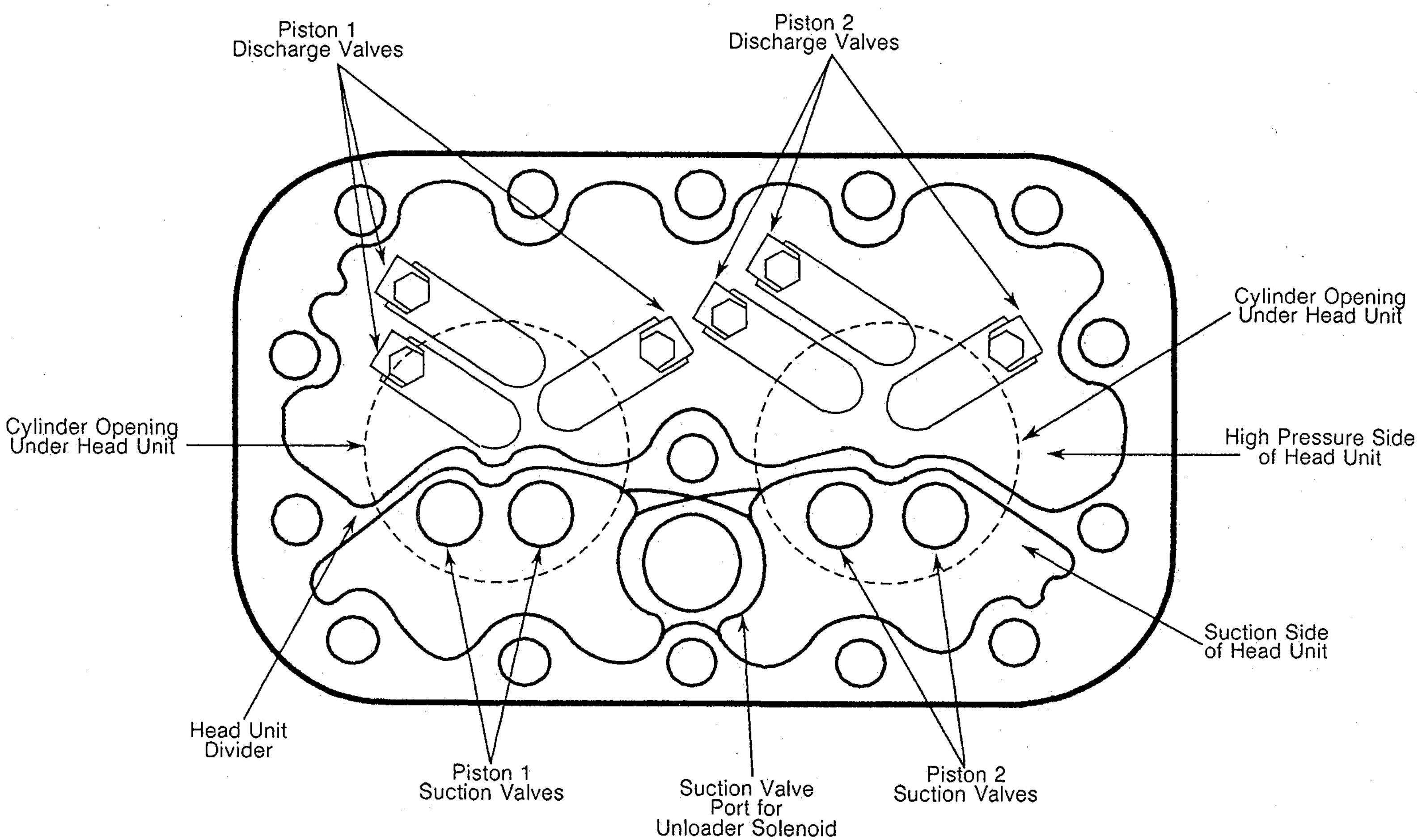

Figure 4-13. Compressor Head Unit (Top View)

A CAPACITY CONTROL control unit (refer to Figure 4-15) operates the unloader solenoid by monitoring the suction pressure. When the computer system is powered on, the unloader solenoid is energized. As the suction pressure increases (a heavier refrigeration load) the CAPACITY CONTROL unit de-energizes the solenoid, allowing gas to enter the suction chamber and cylinders. At this point, all four piston cylinders have suction vapor to compress, increasing the cooling capacity of the compressor.

If suction pressure drops below 40 psig, the CAPACITY CONTROL unit energizes the unloader solenoids, blocking the gas flow into the suction chamber for one pair of pistons. These pistons then have insufficient refrigerant gas to compress and do not develop the pressure necessary to open the discharge reed valves. The pistons without an unloader solenoid still receive suction gas.

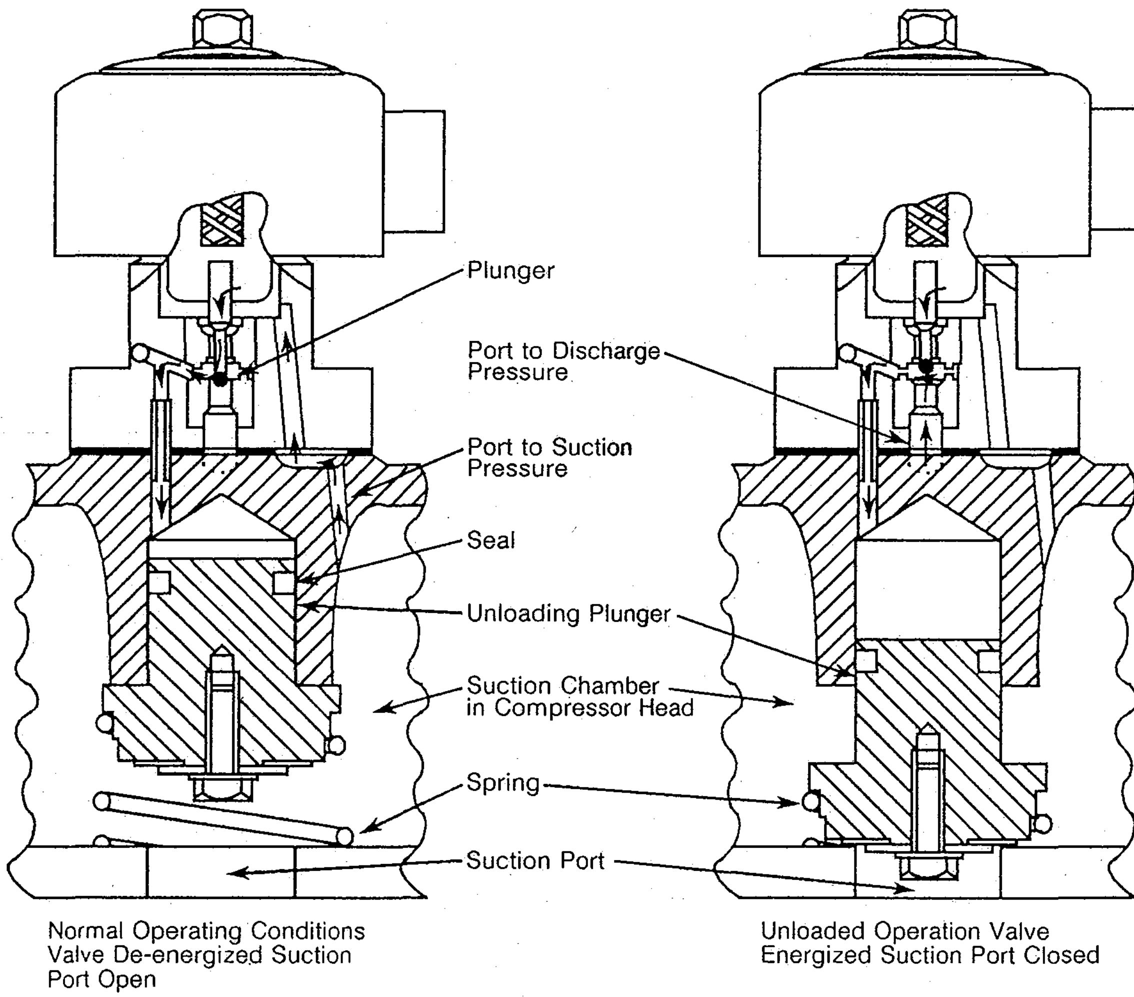

Figure 4-14. Unloader Solenoid Valve

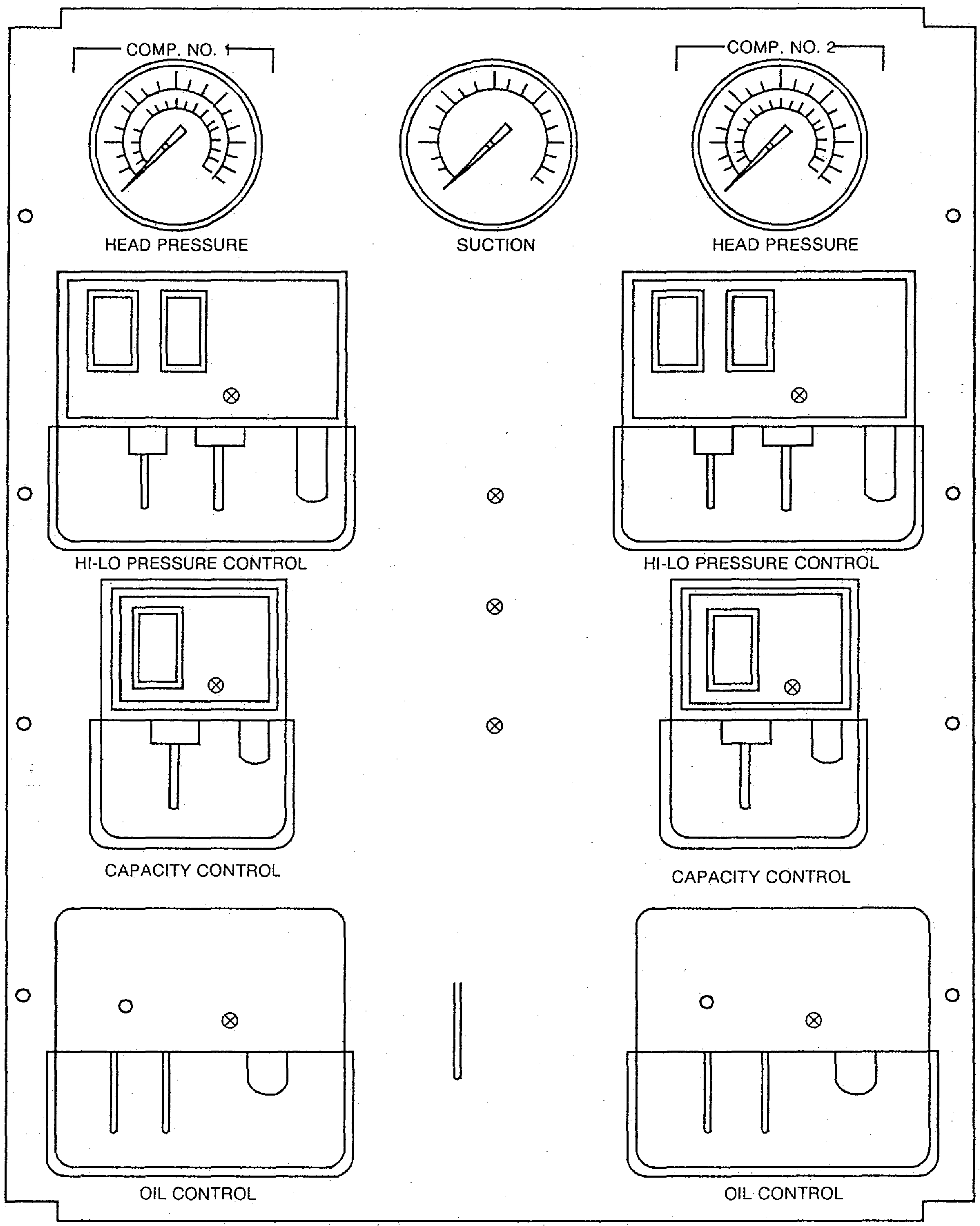

Figure 4-15. RCU-1 Control Panel

Oil Pump

The oil pump lubricates the compressor's crankshaft and pistons; it is gear driven from the end of the crankshaft. Because the compressor is lubricated, a small amount of 3GS grade oil is mixed with the refrigerant and is found throughout the condenser/receiver.

Oil Sight Glass

The oil sight glass is located on the side of the compressor crankcase. It is used to monitor the amount of oil in the compressor. When the compressor is not running, oil should cover half of the glass.

Control Panel

The control panel (refer to Figure 4-15) is mounted on the front of the RCU-1. The control panel contains a SUCTION pressure gauge, two HEAD PRESSURE gauges, two OIL CONTROL control units, two HI-LO PRESSURE CONTROL control units, and two CAPACITY CONTROL control units.

SUCTION Gauge

The SUCTION gauge measures the pressure entering the suction side of the compressor head unit. A normal suction pressure reading is between 45 psig and 70 psig.

HEAD PRESSURE Gauge

Compressors 1 and 2 have independent HEAD PRESSURE gauges. These gauges monitor the high-pressure side of the compressor head units. A normal head pressure reading is between 190 psig and 230 psig.

OIL CONTROL Control Unit

Compressors 1 and 2 have independent OIL CONTROL control units. The function of the OIL CONTROL control unit is to monitor the oil pressure of the compressor. If the oil pressure differential falls below 9 psig for a period of more than 2 minutes, the OIL CONTROL control unit shuts off the compressor. The reset button on the OIL CONTROL control unit must be pushed before the compressor can be reactivated.

HI-LO PRESSURE CONTROL Switch

A separate HI-LO PRESSURE CONTROL control unit with two gauges exists for each compressor. The gauge on the left monitors the high-pressure side of the compressor head unit. The switch automatically shuts the compressor off if the head pressure exceeds 275 psig. The reset button on the switch must be pressed to restart the compressor.

The gauge on the right and the gauge on the CAPACITY CONTROL control unit operate together to control the power-up and power-down sequence for the compressor.

The indicator on the right of the gauge represents power-up suction pressure; the indicator on the left represents power-down suction pressure. The gauges are preset to control the compressor power-up and power-down sequence before shipment.

CAPACITY CONTROL Switch

Each compressor has a CAPACITY CONTROL control unit. These switches control the unloader solenoid by monitoring the suction pressure.

Electrical Wiring

The junction box for the compressors provides 240Vac for a motor thermal protection sensing device. The protection sensors are mounted in the motor windings. A change in temperature will cause a change in electrical resistance of the sensor, opening a set of contacts.

The two terminals marked Mod Power on the wiring diagram (refer to Figure 4-16) provide the power for the Thermal Sensor Control module. The terminals marked Control CKT are incoming and outgoing wires that connect to the K05 and K06 relay contacts controlled by the sensor control unit. These relay contacts, are in series with the OIL CONTROL and HI-LO PRESSURE CONTROL control units, and provide power to the compressor motor contactor.

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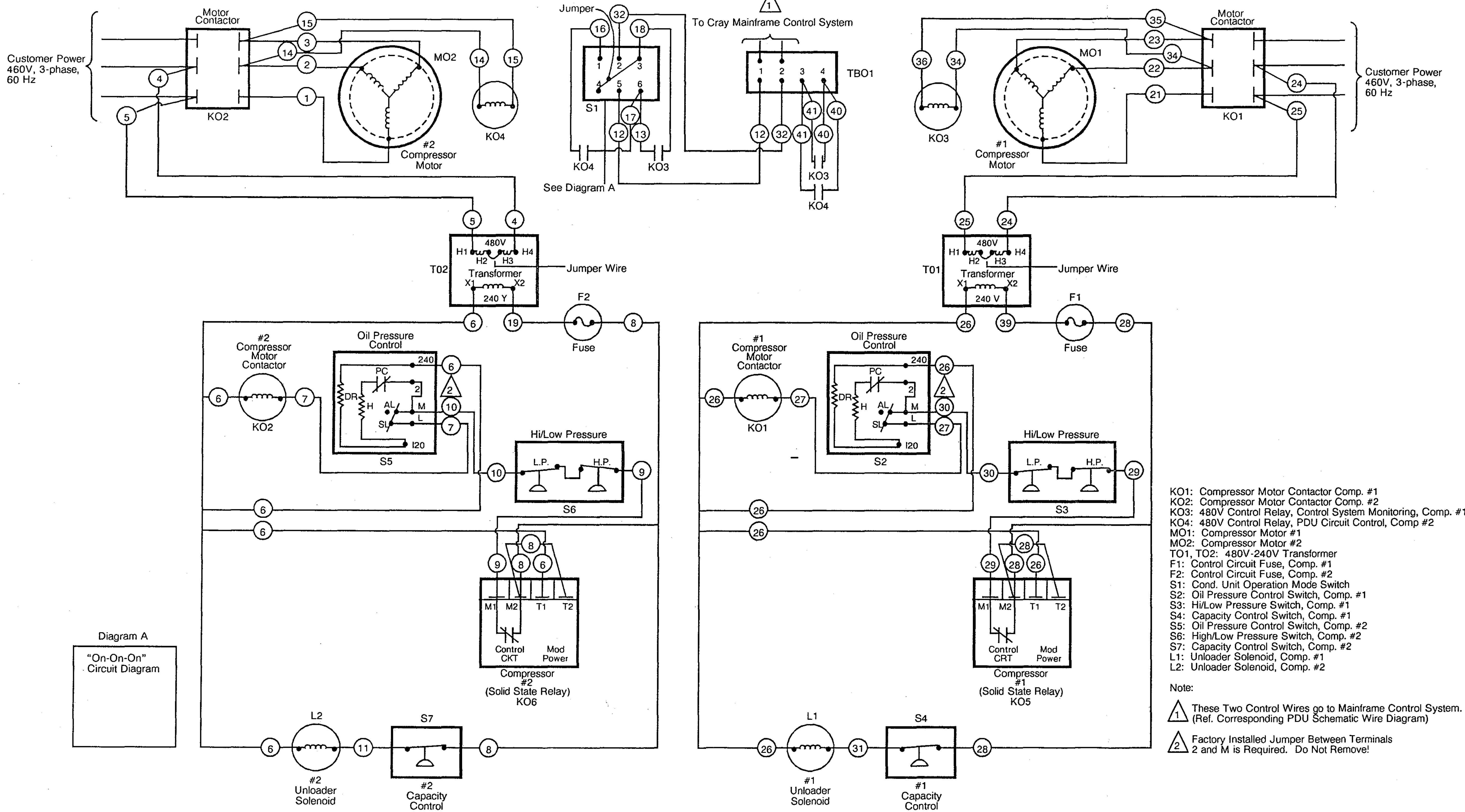

Figure 4-16. RCU-1 Wiring Diagram

Liquid-line Filter Dryer

A liquid-line filter dryer (refer to Figure 4-17) is installed in the refrigeration system to remove any moisture or solid contaminants that could cause a compressor malfunction. Four replaceable filters are contained in the outer shell of the filter (refer to Section 5, "Maintenance and Troubleshooting" for replacement procedures).

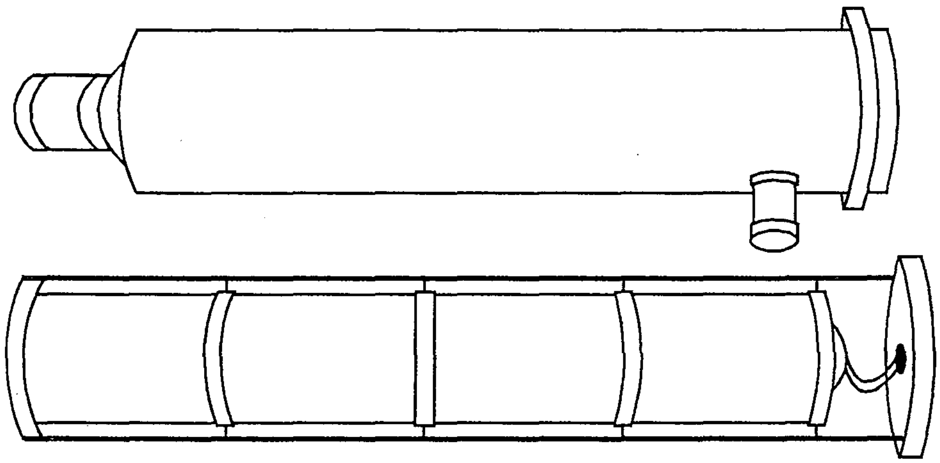

Figure 4-17. Liquid-line Filter Dryer

AUXILIARY RCU

The auxiliary RCU (RCU-2) uses many of the same components as the RCU-1 (refer to "RCU Components". Figure 4-18 shows an RCU-2 configuration.

The following are the components of an RCU-2 (refer to Figure 4-19):

- Suction filter
- Compressor assembly
- Control panel
- Electrical wiring
- Liquid-line filter dryer
- Hot gas bypass system

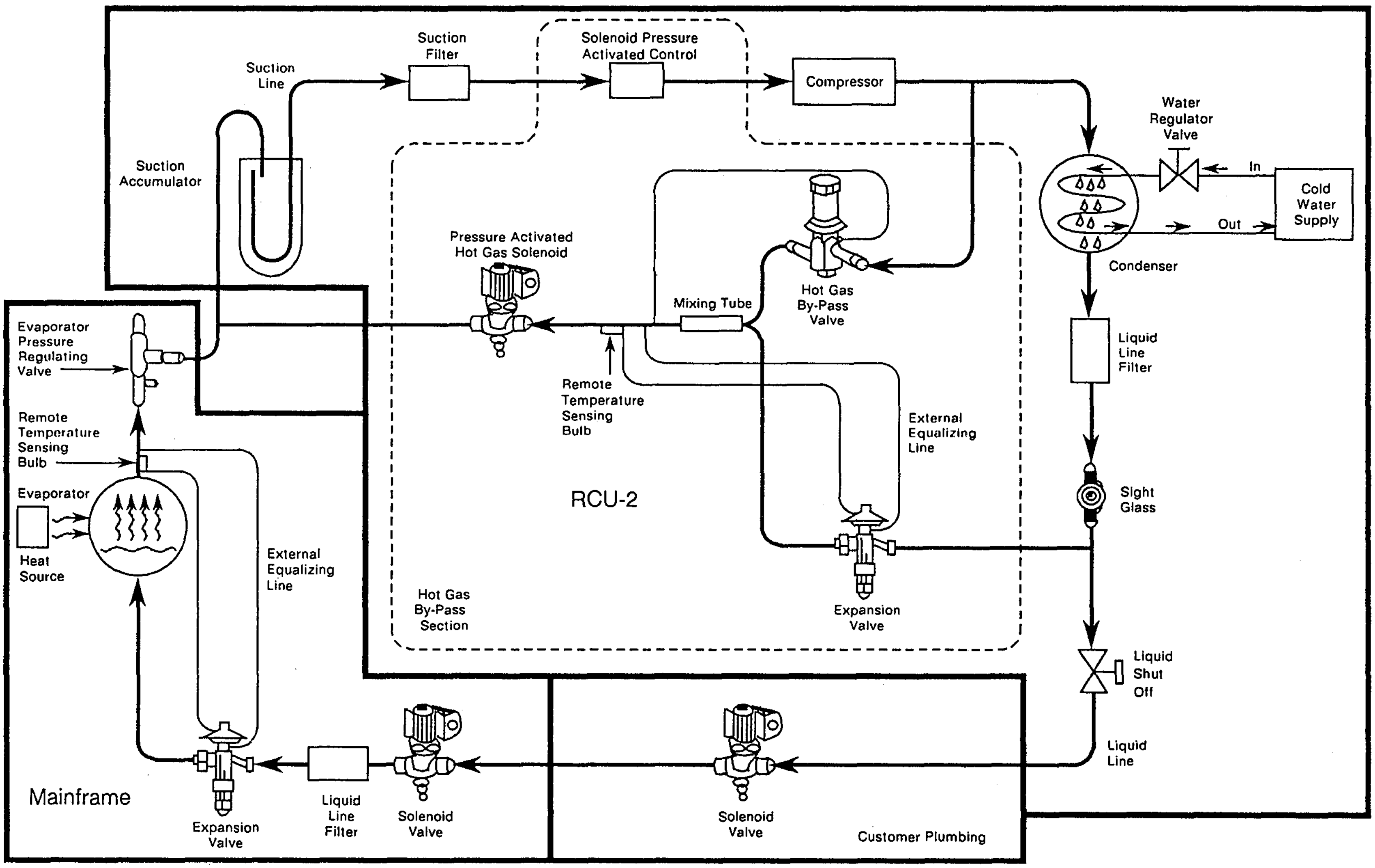

Figure 4-18. RCU-2 Refrigeration System

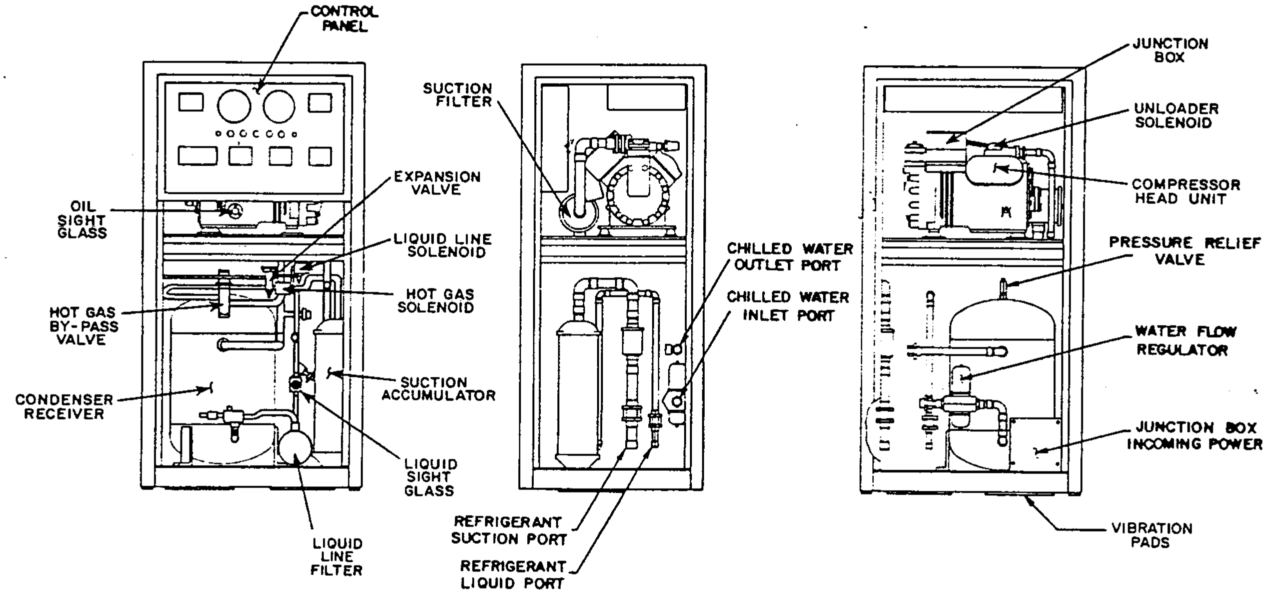

Figure 4-19. RCU-2 Component Locations

Suction Filter

The RCU-2 suction filter (refer to Figure 4-20) protects the compressor from contamination left in the system at the time of installation. If the suction filter becomes clogged, the filter element should be replaced.

Compressor Assembly

The RCU-2 compressor assembly is a single compressor unit that operates in the same manner as the RCU-1 compressor assembly.

Control Panel

The control panel (refer to Figure 4-21) is mounted on the front of the compressor assembly and contains the following components:

- SUCTION PRESSURE gauge
- HEAD PRESSURE gauge
- HIGH HEAD PRESSURE control unit
- LOW HEAD PRESSURE control unit
- CAPACITY CONTROL control unit
- DISCHARGE BYPASS control unit
- LOW SUCTION PRESSURE control unit
- Fault indicators
- OIL PRESSURE control unit

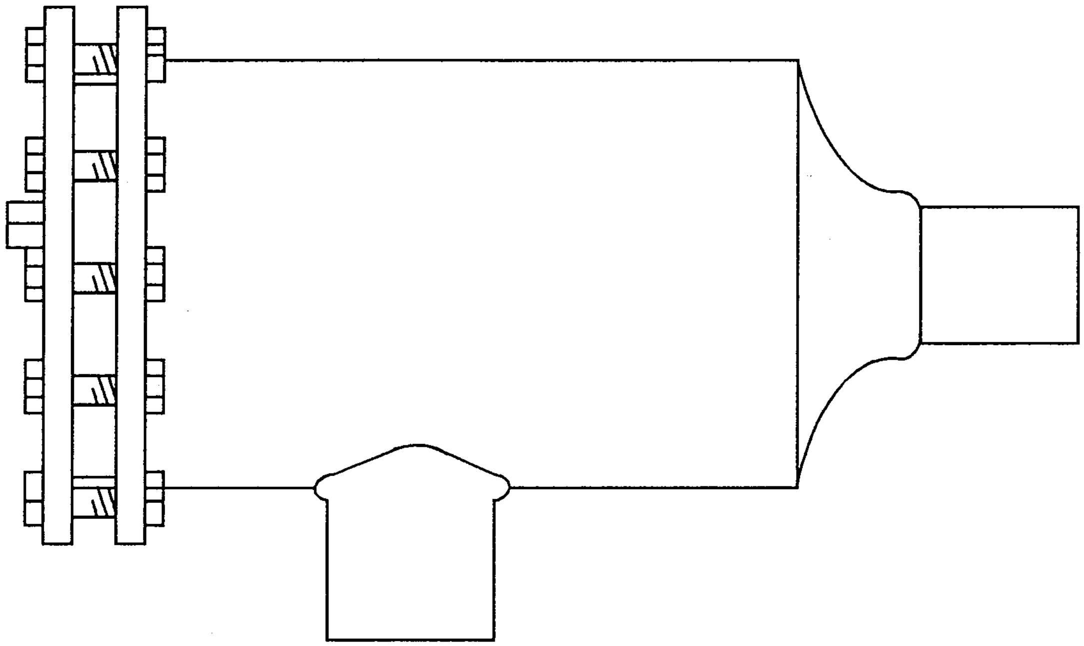

Figure 4-20. RCU-2 Suction Filter

SUCTION PRESSURE Gauge

The suction pressure gauge monitors the pressure entering the suction side of the compressor head unit. A normal range for suction pressure is between 45 psig and 70 psig.

HEAD PRESSURE Gauge

The head pressure gauge monitors the high-pressure side of the compressor head unit. A normal head pressure is between 190 psig and 230 psig.

HIGH HEAD PRESSURE Control Unit

The HIGH HEAD PRESSURE control unit monitors the high-pressure side of the compressor head unit. If the head pressure exceeds 275 psig, the control unit automatically shuts the compressor off. Depress the reset button on top of the control unit to reactivate the compressor.

LOW HEAD PRESSURE Control Unit

The LOW HEAD PRESSURE control unit also monitors the high pressure side of the compressor head unit. If the head pressure falls below 100 psig, the control unit automatically shuts the compressor off. Depress the reset button on top of the control unit to reactivate the compressor.

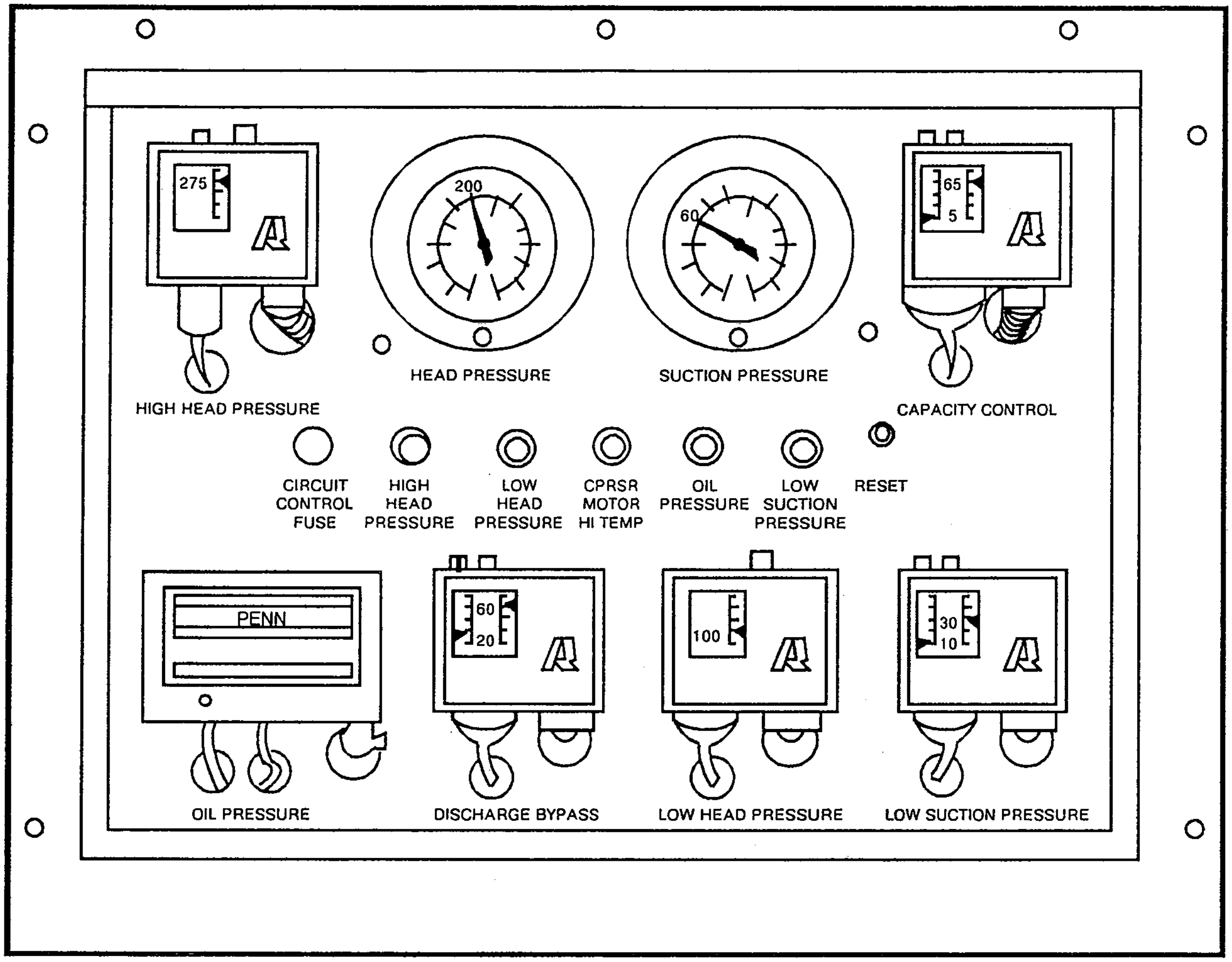

Figure 4-21. RCU-2 Control Panel

CAPACITY CONTROL Control Unit

The capacity control control unit controls the unloader solenoid valve by monitoring the suction pressure.

OIL PRESSURE Control Unit

The OIL PRESSURE control unit monitors the oil pressure of the compressor. If the oil pressure differential falls below 9 psig for a period of more than 2 minutes, the OIL PRESSURE control unit shuts the compressor off. Depress the reset button on the OIL PRESSURE control unit to reactivate the compressor.

DISCHARGE BYPASS Control Unit

The DISCHARGE BYPASS control unit monitors the suction pressure of the refrigeration system. When the refrigeration load decreases and the suction pressure falls below 40 psig, the DISCHARGE BYPASS control unit opens the Hot Gas Solenoid

Valve, creating an added (false) refrigeration load for the system. The solenoid valve is located in the hot gas bypass section of the RCU-2 refrigeration system.

When the DISCHARGE BYPASS switch is energized, it allows liquid refrigerant and hot discharge gas to be metered by the expansion and Hot Gas Bypass valves. These valves provide the added refrigeration load.

When the evaporators and the hot gas bypass section of the RCU-2 create a load large enough to raise the suction pressure above 60 psig, the DISCHARGE BYPASS control unit de-energizes, closing the Hot Gas Bypass and Liquid-line Solenoid valves.

LOW SUCTION PRESSURE Control Unit

The LOW SUCTION PRESSURE and CAPACITY CONTROL control units operate together to control the power-up and power-down sequences of the compressor. The needle indicator on the right of each control unit represents power-up suction pressure. The indicator on the left represents the power-down suction pressure. Both control units are preset before shipment.

Once the computer system is powered on, pressing the LOW SUCTION PRESSURE control unit powers up the compressor. As the refrigeration load increases to 35 psig suction pressure, the two pistons without unloader solenoid valves compress the gas and discharge it to the high-pressure side of the compressor head unit.

As the refrigeration load increases suction pressure to 75 psig, the CAPACITY CONTROL control unit turns off, energizing the solenoid valve. At this time, the suction chamber for the second set of pistons receives suction gas to compress. The compressor is now operating at its highest capacity.

When the refrigeration load begins to decrease, the LOW SUCTION PRESSURE and CAPACITY CONTROL control units regulate the systematic power-down of the compressor.

The LOW SUCTION PRESSURE control unit also monitors the suction pressure to ensure safe operating conditions. If the suction pressure falls below 20 psig while the compressor is running, the control unit causes the control circuitry to shut the compressor off. After a Low Suction Pressure fault, the LOW SUCTION PRESSURE control unit automatically resets when the suction pressure increases to 35 psig.

Fault Indicators

Compressor fault indicators are located in the center of the control panel. Each indicator is labeled and lights to indicate any compressor failure. Depress the RESET button to the right of the indicators to clear the fault indicators.

Electrical Wiring

A wiring diagram for the RCU-2 is provided in Figure 4-22. Wire 14 provides 240 Vac of power for the motor thermal protection sensor device. The protection sensors are mounted within the motor windings. A change in temperature causes a change in electrical resistance of the sensors. The Thermal Sensor Control module detects the change in resistance and opens a set of contacts connected to the Sensor Control unit.

Wires 24 and 38 are the incoming and outgoing wires connected to the K01 relay contacts controlled by the Sensor Control unit.

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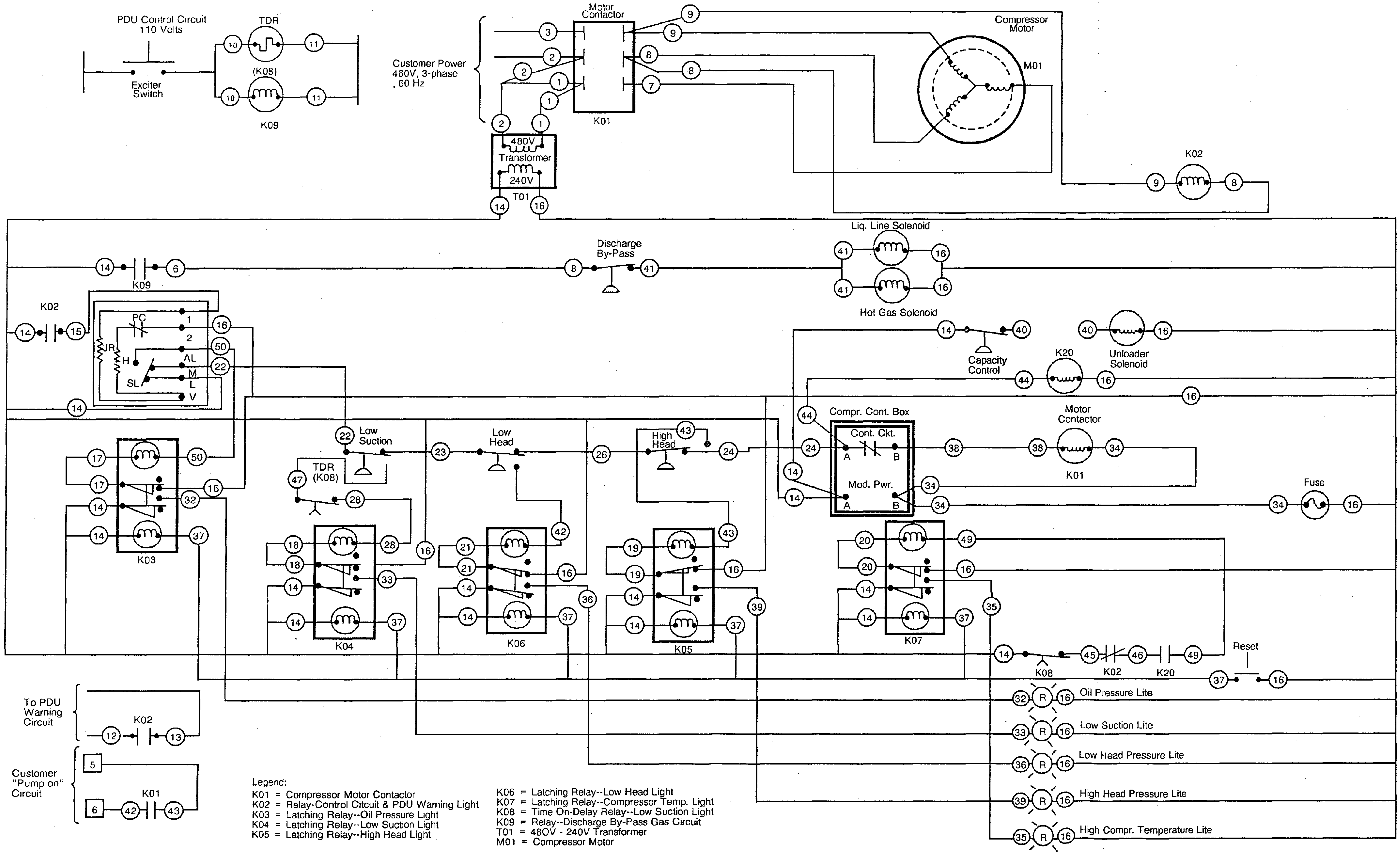

Figure 4-22. RCU-2 Wiring Diagram

Liquid-line Filter Dryer

A liquid-line filter dryer (refer to Figure 4-23) is installed in the refrigeration system to remove any moisture or solid contaminants that could cause compressor malfunction. A replaceable filter is contained within the outer shell. Replacement procedures are described under "Liquid-line Filter Replacement" in section 5 of this manual.

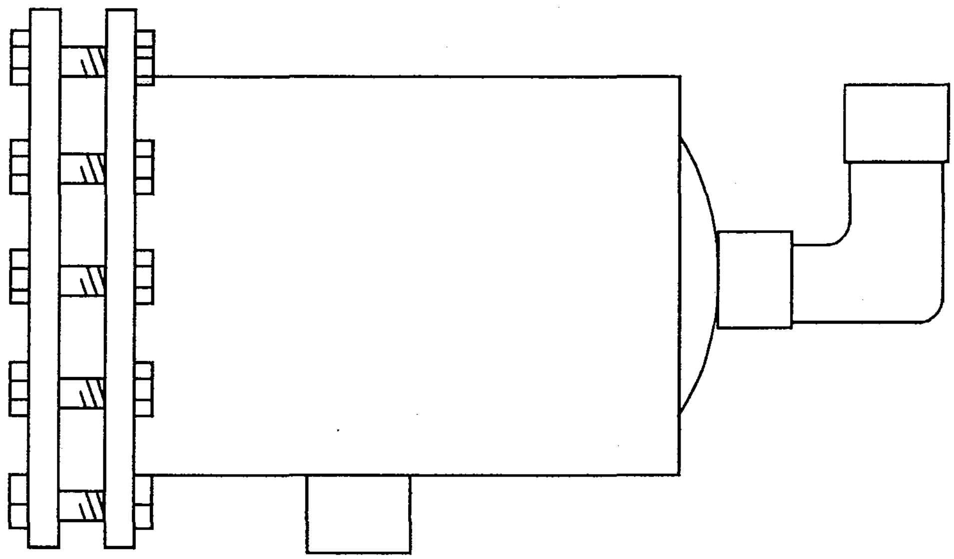

Figure 4-23. RCU-2 Liquid-line Filter Dryer

Hot Gas Bypass System

The hot gas bypass system (refer to Figure 4-18) creates an added refrigeration load for the compressor if the evaporators fail to maintain an acceptable suction pressure. The following are components of the hot gas bypass system:

- Hot Gas Bypass valve
- Discharge Bypass switch
- Pressure activated solenoid (hot gas and liquid line)
- Expansion valve
- Mixing tube

The Hot Gas Bypass valve (refer to Figure 4-24) is externally controlled and regulates the compressor discharge gas flow. The gas from the high-pressure side of the compressor enters the valve through the inlet port. The gas passes between the valve piston and seat and exits the valve through the outlet port, which connects to the mixing tube. As the gas passes through the mixing tube, it creates a false refrigeration load.

The operation of the Hot Gas Bypass valve is controlled by three pressures that control the diaphragm position: the adjustable spring pressure, the external equalizing line pressure, and the suction pressure. The adjustable spring pressure is equalized by the suction pressure fed back through the external equalizing line. This configuration guarantees a minimum opening between the valve position and seat. If the

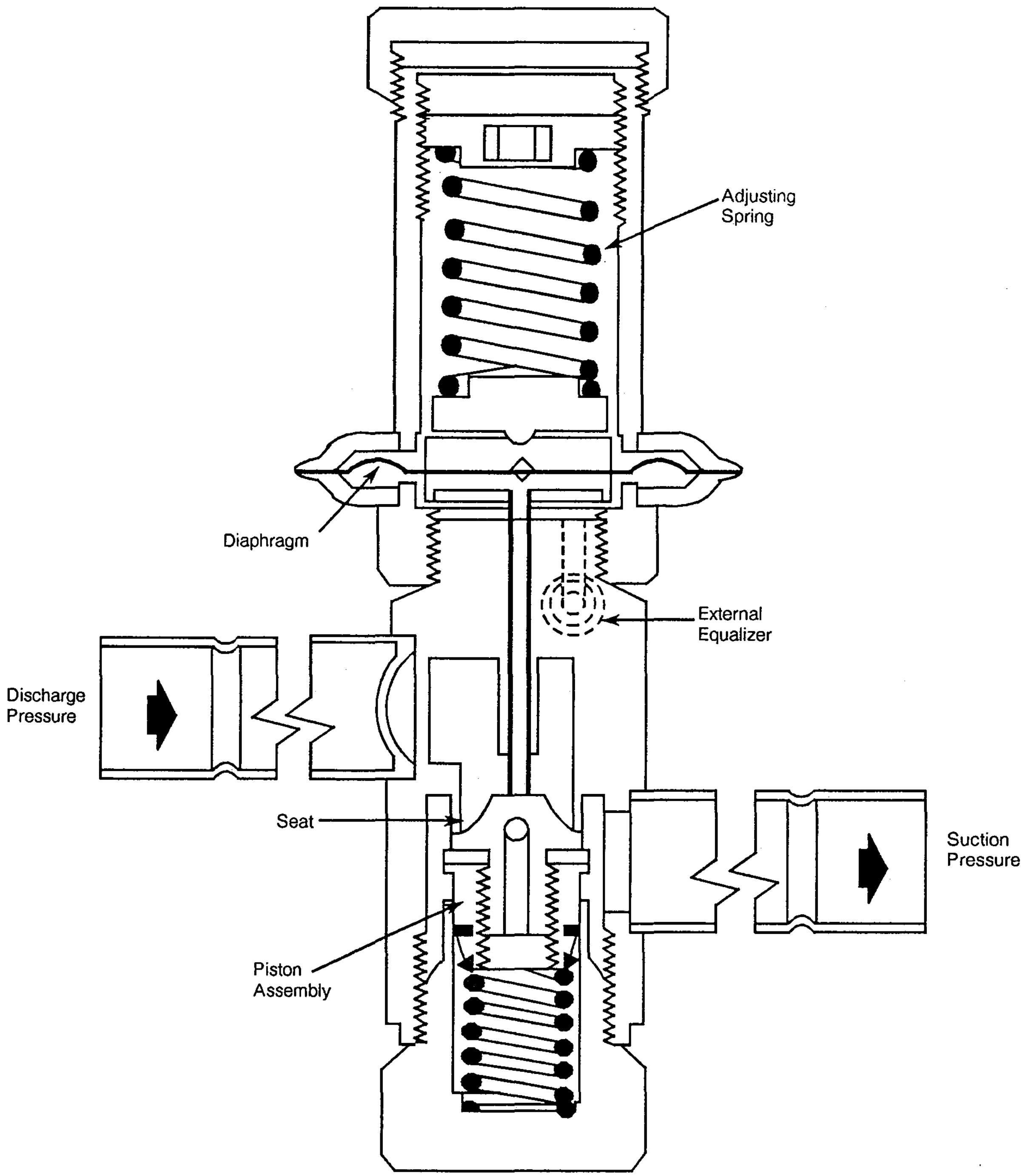

Figure 4-24. Hot Gas Bypass Valve

suction pressure decreases, the piston moves downward to enlarge the valve opening. This allows more discharge gas to flow through the valve and enter the mixing tube, creating a greater refrigeration load and suction pressure.

If the suction pressure increases, the piston assembly is forced upward decreasing the valve opening. The amount of discharged gas in the mixing tube is reduced, causing a reduced refrigeration load and suction pressure.

HEAT EXCHANGE UNIT (HEU)

The Heat Exchange Unit (HEU) in the CRAY Y-MP computer system is a dielectric fluid-to-Freon heat exchange system. The HEU, which is located within the computer room, is connected by underfloor piping to the mainframe and the RCU-1. The HEU heat exchange subassembly (refer to Figure 4-25) is a compact plate-to-plate structure contained within the HEU that provides the exchange of heat between dielectric fluid used to cool the mainframe and Freon. In the heat exchange subassembly the Freon and dielectric fluid travel perpendicular to each other between plates in cross-counter flow channels.

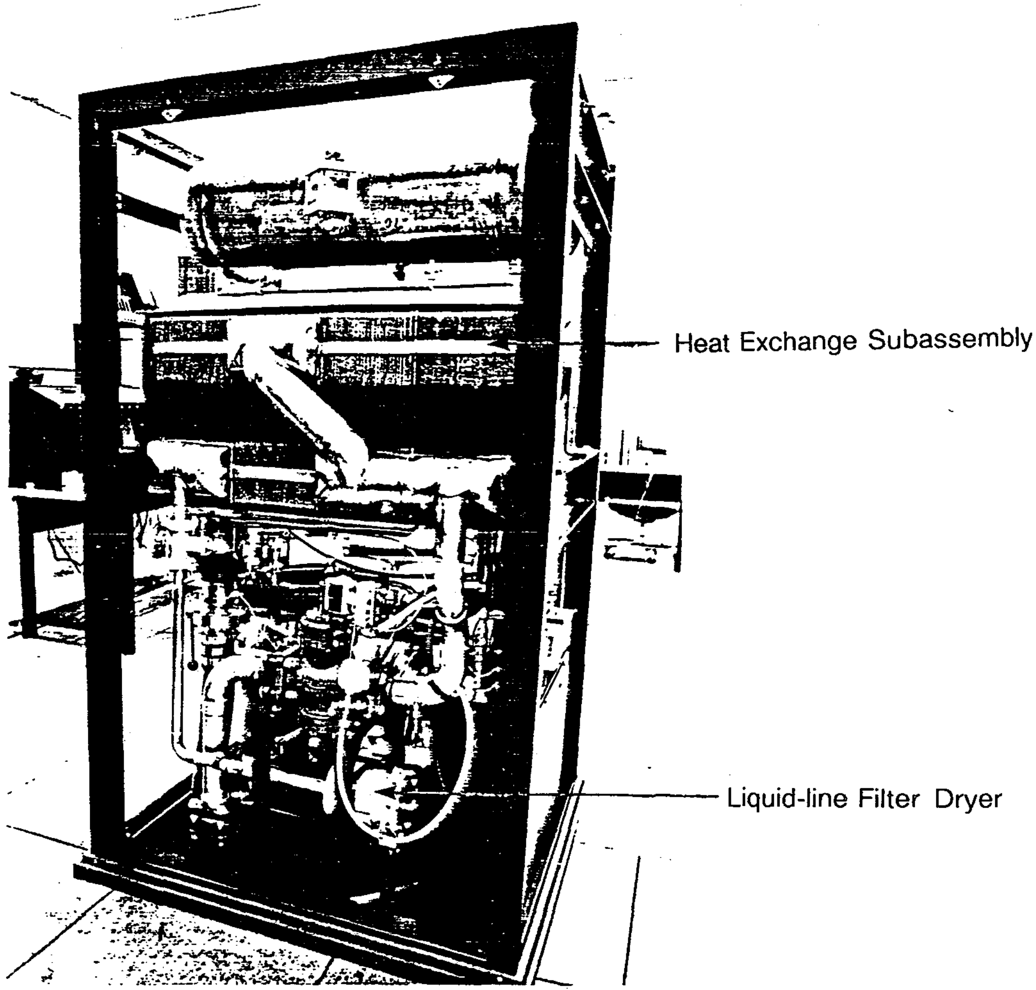

Figure 4-25. CRAY Y-MP Heat Exchange Unit

The nominal cooling capacity of the HEU is 40 tons or 480,000 BTUs per hour. The amount of heat exchange in the heat exchange subassembly, or evaporator portion of the HEU is approximately 432,000 BTU/hr.

As shown in Figure 4-10, the cool dielectric fluid from the HEU travels through three sets of flow meters and valves on the mainframe intake manifold. The flow meters, control valves, supply and return manifolds, along with all refrigerant piping for dielectric fluid are located under the computer room floor. The valves and flow meters are the inlets to three flow circuits that route the flow of dielectric fluid through the mainframe (refer to Figure 4-26). There is one path for dielectric fluid through the modules, one path through the power supply plate, and one path through the power supplies.

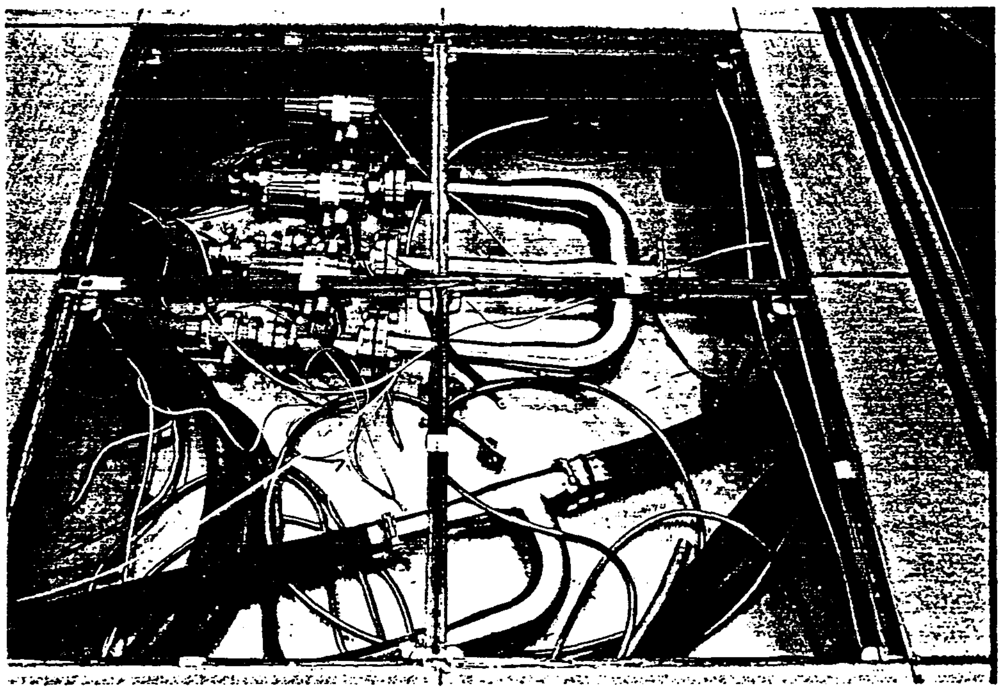

Figure 4-26. Mainframe Intake Manifold (above) and Outlet Manifold

The total flow of dielectric fluid through the cooling system is 205 gpm. The total amounts of flow for the mainframe include 160 gpm through the modules, 30 gpm through the power supply plate, and 15 gpm through the power supplies. The cooling system holds approximately 60 gallons of dielectric fluid.

On the return line from the mainframe, dielectric fluid flows into a strainer and then an accumulator tank in the HEU [refer to Figure 4-27, HEU (side view)]. From the accumulator tank the dielectric fluid goes to a centrifugal pump. The pump discharges dielectric fluid back into the heat exchange subassembly at 100 psig.

The temperature of the dielectric fluid is approximately 65 °F (18 °C) going into the intake manifold of the mainframe. On the outlet manifold of the mainframe, the dielectric fluid is approximately 73 °F (23 °C) .

The 50-ton RCU-1 cools the Freon R-22, which is the refrigerant used in the HEU. Freon flows from the RCU-1 in a liquid (supply) line through a solenoid valve and an expansion valve. The expansion valve controls the mass flow of the refrigerant flowing through the heat exchange subassembly. As the pressure of liquid refrigerant is lowered, so is the boiling temperature. A remote temperature sensing bulb monitors the

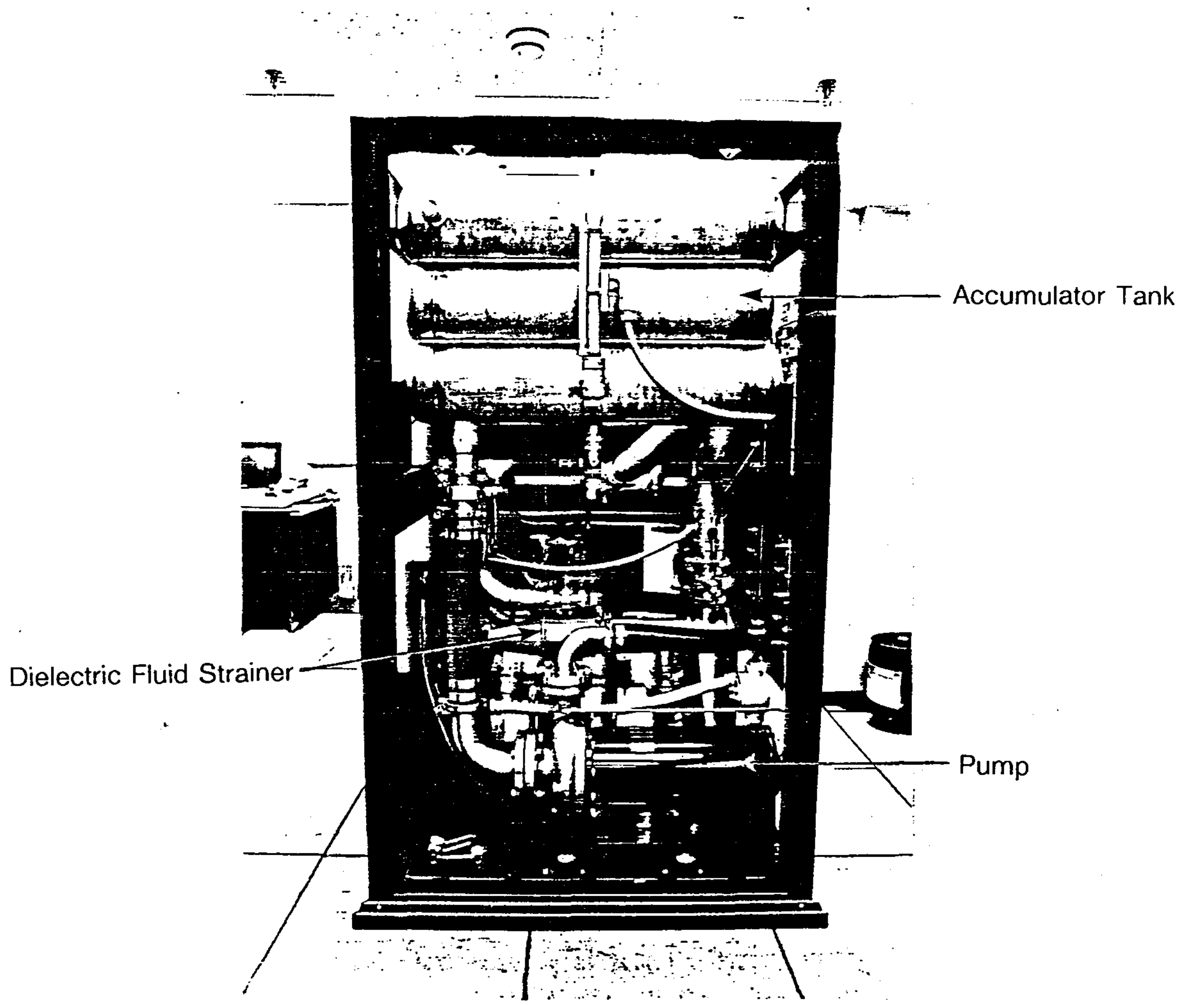

Figure 4-27. HEU (Side View)

temperature of the heat exchange subassembly and controls the expansion valve externally.

Liquid refrigerant enters the expansion valve from the RCU and flows between the needle and valve seat, exiting to the heat exchange subassembly as a vaporous liquid. In the heat exchange subassembly, the refrigerant is exposed to a low vapor pressure where it further vaporizes and absorbs heat.

Inlet pressure regulator Valve

From the heat exchange subassembly, superheated Freon travels to the Evaporator Pressure Regulating (EPR) valve, which maintains the desired heat exchange subassembly pressure and temperature. The valve is located on the outlet of the heat exchange subassembly on the suction line.

The vaporized refrigerant enters the EPR valve through the inlet port, flows between the valve seat and the seat disc, and exits the valve through the outlet port. The outlet port is connected to the suction line. The Freon then travels from the EPR valve back to the RCU-1.

HEU Control System Indicators

Two indicators on the control system console of the mainframe monitor various conditions of the HEU. A Heat Exchange Warning indicator is located on the control system console and signals either a Low Liquid-level condition or a Compressor fault on the HEU. An HEU High-pressure fault causes a Heat Exchange fault, which is also displayed on the console. The Heat Exchange fault is caused when dielectric fluid pressure at the HEU pump exceeds ~~120~~ psig. These faults can also be monitored on the HEU control panel (refer to Figure 4-28).

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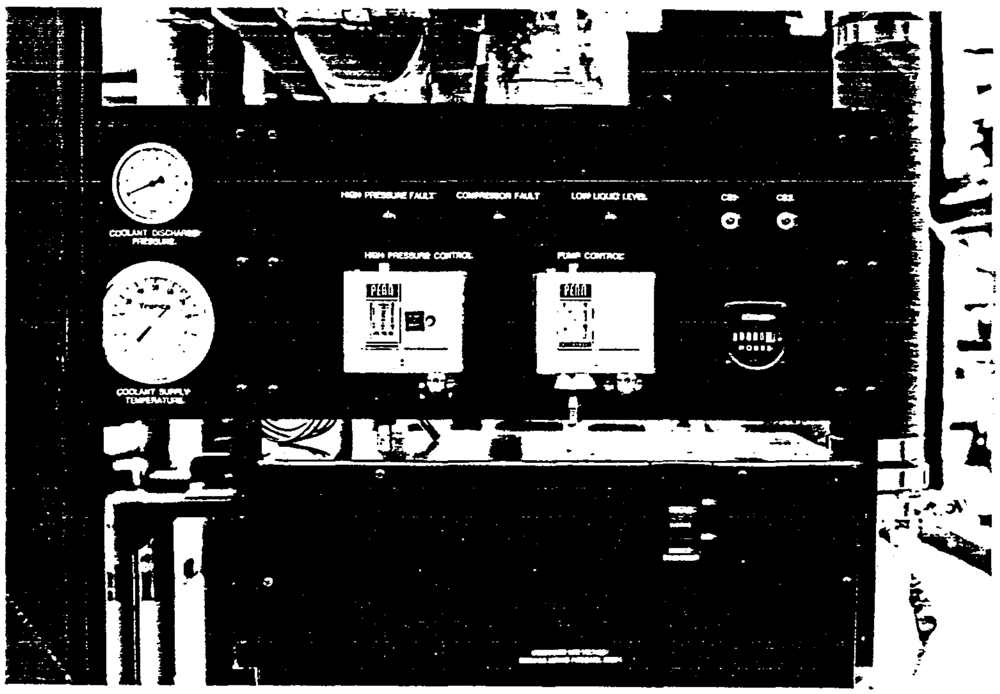

Figure 4-28. HEU Control Panel

HEU Electrical Theory of Operation

Major control signals for HEU operation are sent between the J1 connector and the CRAY Y-MP control system (refer to Figure 4-29, HEU Wiring Diagram). J1 connector signals include the inputs from the Stop/Start switches on the control system console (On/Off); as well as signals from within the HEU, including the HEU Warning signal for the Low Liquid-level and Compressor Fault signals, and the HEU Fault signal for the High-pressure Fault signal.

When initiating an HEU power-up or power-down, the J1 connector On/Off signals provide the inputs to the contacts of relay K2. To start the HEU pump motor a signal must be sent from the K2 relay through the Pump Motor Control relay, K3. This relay is normally closed unless a High-pressure fault exists and it allows completing the circuit to the pump motor start relay, K1.

The J1 connector receives a signal transmitted to the control system console on the mainframe when the contacts at the K4 relay close to send a Low Liquid-level signal. The signal is the result of a low level of dielectric fluid measured at the HEU.

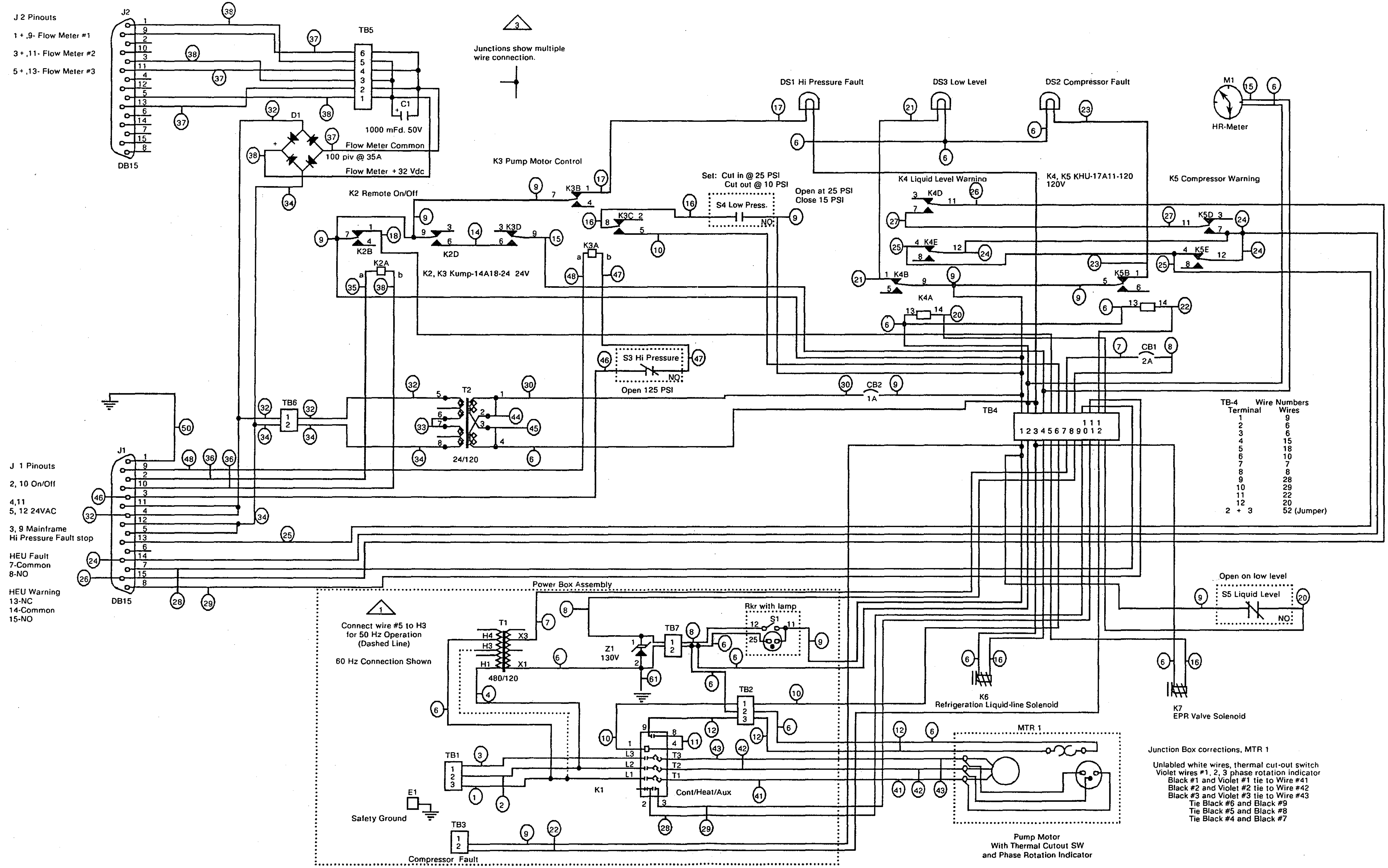

Figure 4-29. HEU Wiring Diagram

A Compressor Fault or Low Liquid-level signal is sent to the J1 connector as an HEU Warning signal. The HEU Warning signal is sent to the control system console when the K5 relay contacts close. Either a Compressor Fault or Low Liquid-level signal causes the Heat Exchange Warning indicator to light and alarm to sound at the CRAY Y-MP control system console.

Relay K3 is part of the High-pressure Fault control circuit that monitors dielectric fluid discharge pressure of the pump. If the pressure rises to 120 psi or more, the pump turns off. A signal from the K3 relay is sent across the J1 connector and registered as a Heat Exchange fault on the control system console.

A major connection point within the HEU is the terminal block, TB4. TB4 receives inputs from the Remote On/Off relay, K2, as well as from the Pump Motor Control relay, K3. Other inputs to TB4 are from the Liquid Level Warning relay, K4; the Compressor Warning relay, K5; and the Refrigerant Liquid-line Solenoid relay, K6.

Pressure switch S4 monitors the evaporator pressure in the HEU. The S4 switch contacts close at 25 psig in the evaporator, turning on the pump motor. The contacts open at 15 psig, turning off the pump.

The HEU receives 460 Vac from commercial power mains. (A 460-Vac, 60-Hz input is used by the dielectric fluid pump motor in domestic installations; a 380-Vac, 50-Hz input is used in overseas installations.) As shown in Figure 4-29, this voltage is reduced by the T1 transformer to 120 Vac. The 120 Vac is sent to the TB4 terminal block and then to the T2 transformer, where voltage is stepped down further to 24 and 12 Vac. The voltage is rectified for approximately a 12/24 Vdc output voltage at the D1 rectifier. This voltage is sent across the J2 connector for flow meter operation at the inlet manifold to the mainframe.

HEU Components

Major components of the HEU include the dielectric fluid pump, expansion valve, EPR valve, solenoid valve, High-pressure switch, and liquid-line filter dryer. This subsection describes each component.

Dielectric fluid Pump

The dielectric fluid pump (refer to Figure 4-27) is a centrifugal unit with a squirrel cage induction electric motor. The pump and motor are contained together in a single hermetically sealed unit. The pump impeller is a closed type and is mounted on one end of a rotor shaft that extends from the motor section into the pump casing. The rotor is submerged in the dielectric fluid being pumped and is therefore sealed to isolate the motor parts from contact with the dielectric fluid. The stator winding is also sealed to isolate it from the dielectric fluid. Bearings are submerged in the dielectric fluid and are automatically lubricated.

The dielectric fluid pump and motor are mounted on a fabricated steel base plate. The pump has only one moving part, a combined rotor-impeller assembly that is driven by the magnetic field of the induction motor.

The electrical requirements of the pump motor include input voltage of 460-Vac, 3-phase, 60-Hz. power or 380-Vac, 3-phase, 50-Hz power. The motor is a 20 hp model, which operates at 3,450 rpm at 60 Hz, or 2,875 rpm at 50 Hz. The pump circulates dielectric fluid at 205 gpm and at a pressure of 115 psi.

Expansion Valve

The expansion valve in the HEU controls the flow of Freon vapor and liquid through the heat exchange subassembly (refer to Figure 4-30). The expansion valve is externally controlled by a remote temperature sensing bulb that monitors the temperature of the heat exchange subassembly. As the pressure of liquid Freon is lowered, so is the boiling temperature. The expansion valve used with the HEU has a nominal capacity of 36 tons (432,000 BTUs per hour.).

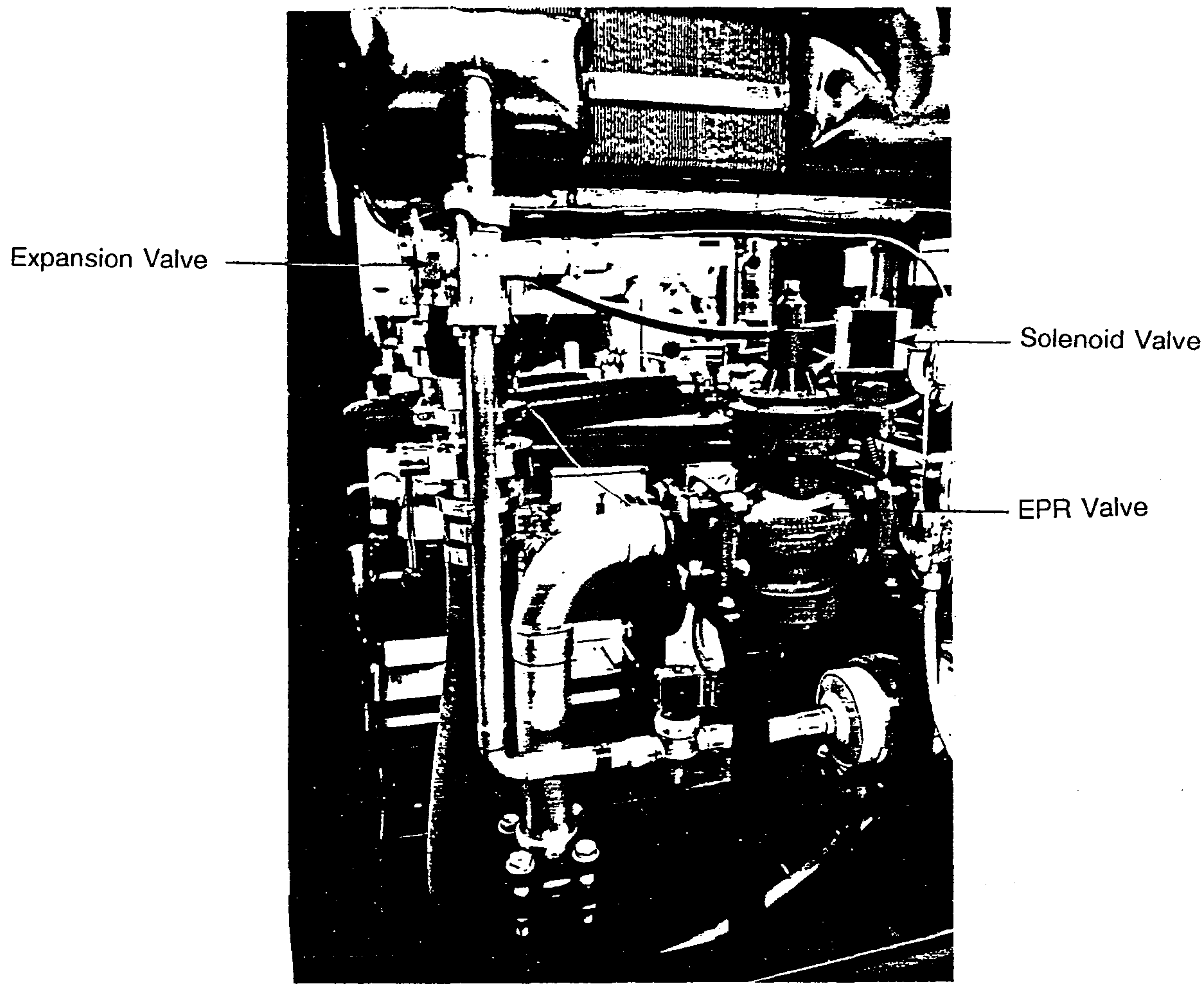

Figure 4-30. Expansion, EPR, and Solenoid Valves

Evaporator Pressure Regulator (EPR) Valve

The EPR valve (refer to Figure 4-30) maintains a desired evaporator pressure and temperature during changing load conditions. The valve is located on the outlet of the heat exchange subassembly. The EPR valve used for the CRAY Y-MP system is solenoid pilot operated. It uses evaporator pressure and requires a minimum 2 psig evaporator pressure drop to fully open.

Solenoid Valve

The solenoid valve controls the flow of refrigerant through the liquid and vapor lines (refer to Figure 4-30). It stops the flow of refrigerant into the evaporator when the machine is powered off. The valve consists of a body and an iron core plunger seated in the valve orifice. The valve is controlled by an electrical solenoid coil that is normally closed. When the solenoid is energized, the plunger lifts and opens the valve.

High-pressure Switch

The High-pressure switch contains pressure contacts at the discharge port of the dielectric fluid pump that monitor for a 120 psig value. At 120 psig, the switch circuit initiates a shutdown of the system through a Heat Exchange fault recorded by the control system. The normal operating pressure of the system is 100 psig.

Liquid-line Filter Dryer

A liquid-line filter dryer (refer to Figure 4-25) is installed in the refrigeration system to remove any moisture or solid contaminants that could cause compressor malfunction. A replaceable filter is contained within the outer shell (refer to "Liquid-line Filter Replacement" in Section 5).

5 - MAINTENANCE AND TROUBLESHOOTING

This section of the manual covers maintenance and troubleshooting information for the CRAY Y-MP Power Distribution and Refrigeration systems.

NOTE: This section provides information for the control system, Heat Exchange Unit (HEU), Refrigeration Condensing Unit (RCU), Motor Generator Set (MGS), power supplies, and mainframe components involved with power distribution and refrigeration; however, maintenance and troubleshooting information available at this time is primarily limited to the RCU, HEU, and MGS.

RCU-1 and RCU-2 MAINTENANCE

This section provides information on RCU-1 and RCU-2 maintenance. Details on tools, preventive maintenance, troubleshooting, and maintenance procedures are covered.

Required Tools

This subsection describes the following tools necessary to maintain a refrigeration system:

- Manifold gauge
- Temperature probe
- Freon Leak detector
- Vacuum pump

Manifold Gauge

A cut-away view of a manifold gauge is provided in Figure 5-1. The manifold forging body is designed so that all three lower flare fittings are connected to each other by an internal passage. The right handwheel controls the flow of Freon through the right side fitting. If the left handwheel is closed, flow is from the center flare to the right flare. The left handwheel and fitting operate in the same manner.

The right side of the manifold (colored red) is the high pressure side and measures pressure, the left side (colored blue) is the low pressure side and measures both vacuum and pressure. An opening from the outside flared fittings allows a vacuum/pressure reading regardless of the position of the handwheels.

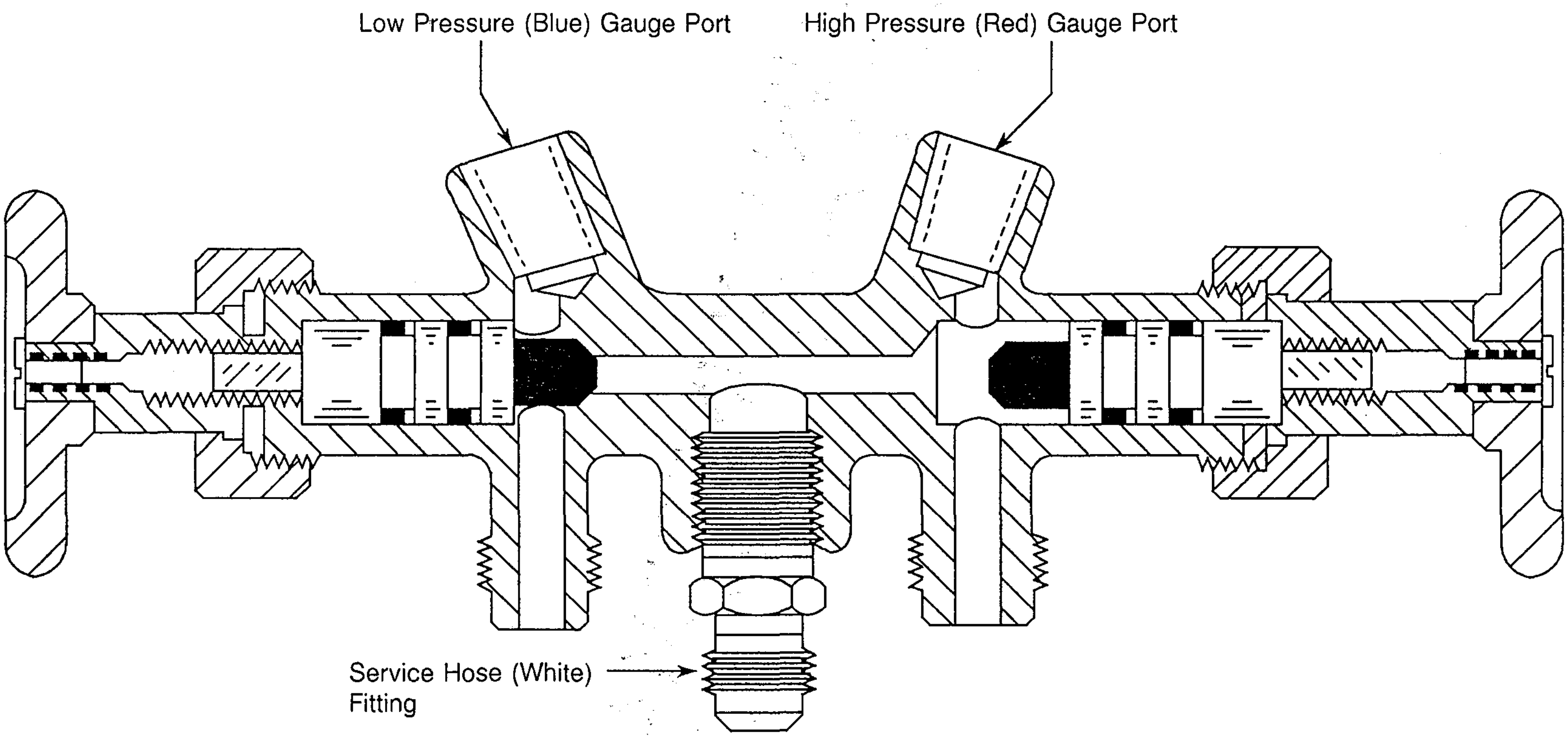

Figure 5-1. Manifold Guage

Temperature Probe

A temperature probe takes temperature readings on the refrigeration system. It is required when making the superheat adjustments on the evaporators.

Either of two probe manufacturers may be used: a Fluke probe is used with a digital Fluke meter, and a Hewlett-Packard probe is used with a digital Hewlett-Packard meter.

Freon Leak Detector

A Freon leak detector detects leaks caused by a poor joint or improper connection.

Vacuum Pump

The vacuum pump creates a vacuum within the closed refrigeration system. Whenever any part of the closed system is exposed to the atmosphere (for example, during filter replacement) air and moisture enter the system, bringing contaminants. These contaminants are removed by using a vacuum pump to pump the exposed part of the system into a vacuum .

When using a vacuum pump, use a manifold gauge to measure the vacuum being created. The following steps outline the operation of a vacuum pump. Operating instructions are also located on the vacuum pump.

WARNING

High pressure hazard. Before using a vacuum pump, power off the RCU in order to isolate the refrigerant in the condenser/receiver. Pressurized Freon that escapes from refrigerant hoses can cause skin irritation or blindness.

The operating time of the pump depends upon the equipment. If a power supply or filter dryer is to be replaced, the recommended operating time is one hour.

1. Power off the refrigeration system and remove the hoses to isolate the affected area of the condenser/receiver.
2. Close the manifold gauge valves and connect the white (center) hose to the vacuum pump. Be sure the connection is tight.
3. Remove the Schrader valve cap of the EPR valve and connect the blue hose to the EPR valve.
4. Review the operating instructions on the vacuum pump and turn the vacuum pump on.

5. Open the left handwheel of the manifold gauge and read the vacuum pressure on the gauge.
6. Check the pressure gauge to ensure that a vacuum has been drawn (between 28 and 30 in. Hg).
7. Close the manifold gauge and turn the vacuum pump off.
8. Re-connect the hoses that were disconnected in step 1.
9. Draw refrigerant into the vacuum by using the Cooling Bypass switch on the control system console of the mainframe, or power on the computer system. (On the IOS and SSD use the cheater switch located on the back of the PDU.) Be sure a positive pressure is obtained (approximately 10 psig).
10. Disconnect the manifold gauge from the vacuum pump.
11. Place the center hose of the manifold gauge in a towel. Relieve some of the pressure by opening the manifold gauge and disconnect the blue hose from the EPR valve.
12. Replace the Schrader valve cap on the EPR valve.

Preventive Maintenance

This subsection provides information on how to perform the weekly system check. It also provides information on preventive maintenance procedures to ensure optimal operation of the refrigeration system.

Weekly Check-off Sheet

Each site is required to complete a Weekly Refrigeration System Check-off Sheet (refer to Figure 5-2). This sheet aids in the monitoring of the refrigeration system and alerts you to potential problems.

Each month the sheet should be sent to Hardware Technical Support (HTS) where a record is maintained and performance is checked. HTS will notify you regarding any problems.

Be sure to complete the site serial number and site name in the upper left corner of Page 1 and the date that each check is made (refer to Figure 5-3 for RCU-1 and Figure 5-4 for RCU-2 for test point locations).

The space on the left side of the sheet is provided for labeling data if more than one RCU is used on a system. Record the mainframe's RCU-1 data first, followed by the data for the RCU-2 [Solid-state Storage Device (SSD) and I/O Subsystem (IOS)]. Allow sufficient space (four lines) between each RCU for the month's readings.

NOTE: Before taking any measurements, allow the RCU-1 or RCU-2 to operate for a minimum of 30 minutes. When recording temperatures and pressures allow the readings to stabilize for 1 minute.

Weekly Refrigeration System Check-off Sheet

Site S/N ____________________

Site Name ____________________

Return Completed Copy on a Monthly Basis
To: International Tech Support
Chippewa Falls

Properties of Saturated Refrigerant R-22

Temp.	Pressure	Temp.	Pressure
20	43	96	186
22	45	98	192
24	48	100	198
26	50	102	204
28	52	104	210
30	55	106	216
32	57	108	222
34	60	110	228
36	63	112	235
38	66	114	242
40	69	116	248
42	72	118	255

Discharge								Suction				Miscellaneous		
Date Checked Dy./Mo./Yr.	Pressure Comp. #1	Pressure Comp. #2	Sat. Temp.	Liquid Line Temp.	Sub Cooling	Hot Gas Temp. Comp. #1	Hot Gas Temp. Comp. #2	Pressure	Sat. Temp.	Temp.	Super Heat	Oil Level #1 #2	L L Sight Glass	Initials
Nominal	190-225PSI		97° - 110°	See Instr.	15° - 20°	170° - 215°		45 - 70 PSI	See Instr.	50° - 60°	15° - 20°	1/4 - 1/2	Green	

Figure 5-2. Weekly Refrigeration System Check-off Sheets (Page 1 of 2)

Page 2

Weekly Refrigeration System Check-off Sheet

Chill H_2O Temp.		Chill H_2O Press.		G.P.M.	Column Temperatures													
In	Out	In	Out		0	1	2	3	4	5	6	7	8	9	10	11	12	

Figure 5-2. Weekly Refrigeration System Check-off Sheets (Page 2 of 2)

The following areas of the Weekly Check Off Sheet must be completed.

Site Serial Number

Enter the system serial number (for example, S/N 5, 26, or 110). No other number is required.

Site Name

Enter the name of your site in this space.

Date Checked

It is imperative for future references that the entire date (day/month/year) be filled in every time the system is checked.

Discharge Pressure

Read the discharge pressure from the panel gauges. For systems that are operating on one compressor, only log the reading of that compressor.

Discharge Saturation Temperature

Look up the discharge saturation temperature on the chart in the upper right-hand corner of Page 1. Use the discharge pressure to determine this value.

Liquid-line temperature

Measure the liquid-line temperature on the liquid line near the sight glass at Test Point 1, (refer to Figure 5-3 or Figure 5-4). This reading varies as the discharge pressure changes.

Subcooling

Subtract the liquid-line temperature from the saturation temperature to obtain the system subcooling value. This value should remain constant. A decrease in the subcooling value on a continuing basis indicates a leak in the refrigeration system.

Hot Gas DischargeTemperature

Measure the hot gas discharge temperature at Test Point 2 (refer to Figure 5-3 or Figure 5-4) on the hot gas discharge line within 1 ft (.305 m) of the compressor service valve. Systems operating on one compressor should only record that value. The hot gas temperature should not exceed 225 °F (107 °C).

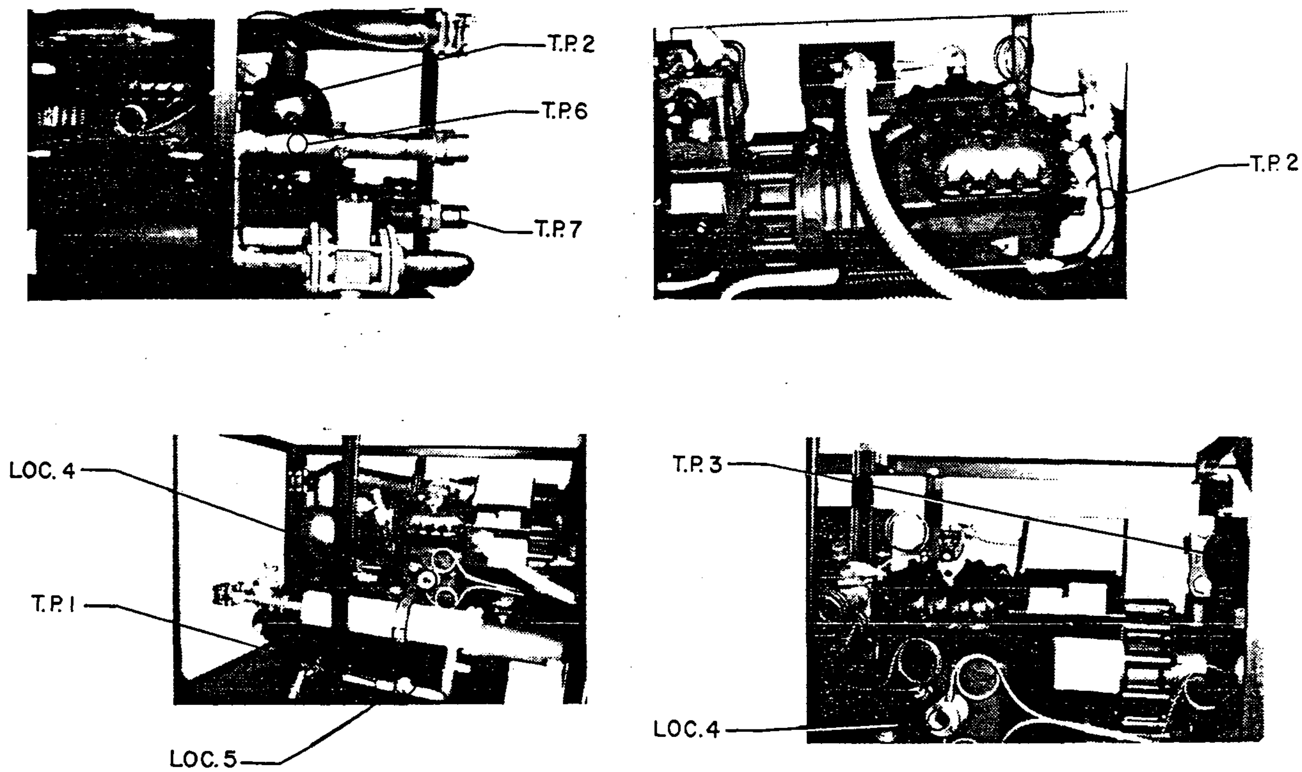

Figure 5-3. RCU-1 Test Point Locations

Suction Pressure

Check the suction pressure from the panel gauges. The pressure should not vary more than 3 psig for normal operating conditions.

Suction Saturation Temperature

Look up the suction saturation temperature on the chart in the upper right-hand corner of Page 1 of the Weekly Check-off Sheet. Use the suction pressure to determine this value.

Suction Temperature

Measure the suction temperature on the suction line at Test Point 3 (refer to Figure 5-3 or Figure 5-4) within 1 ft (.305 m) of the compressor service valve. The suction temperature should not exceed 65 °F (18 °C).

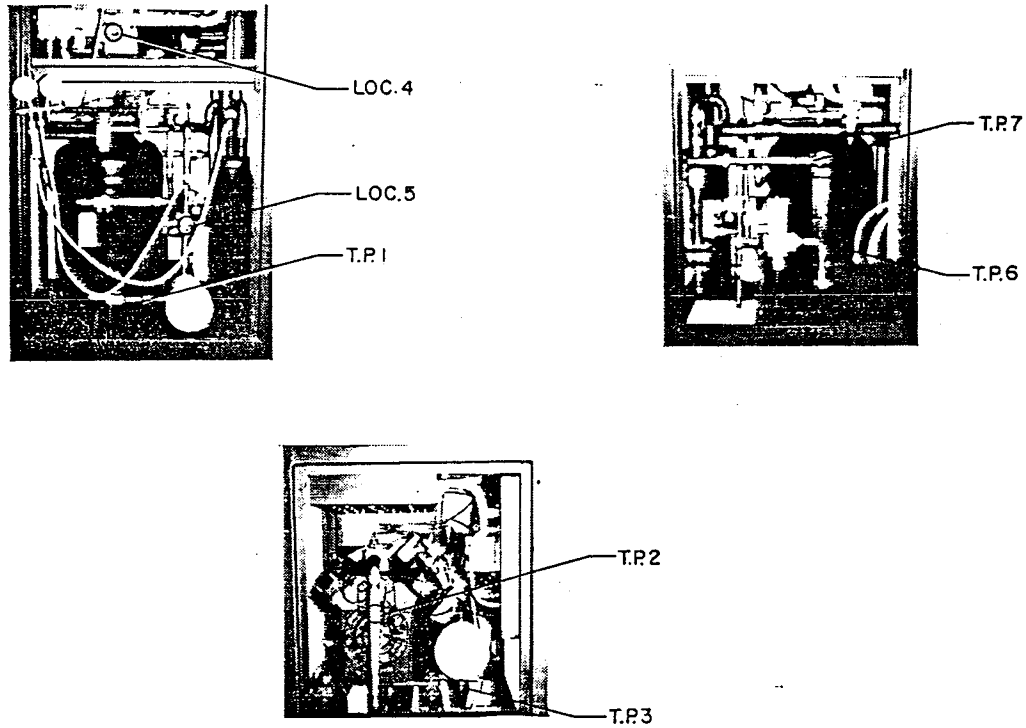

Figure 5-4. RCU-2 Test Point Locations

Superheat

Subtract the saturation temperature from the suction temperature to obtain the system superheat.

Oil Level

Observe the compressor oil level through the oil sight glass at Location 4 (refer to Figure 5-3 or Figure 5-4). The oil level in the sight glass should not be less than 1/4 or more than 1/2 full.

Liquid-line Sight Glass

The liquid-line sight glass, found at Location 5 (refer to Figure 5-3 or Figure 5-4), allows observation of the refrigerant flow. The flow should not contain any surge of bubbles. If bubbles exist, the system may require additional refrigerant.

The sight glass also shows the amount of moisture in the RCU. If the dot in the center of the sight glass is green, the system is considered moisture free; a yellow dot indicates that there is too much moisture. If a system has too much moisture, check for leaks and replace the liquid-line filter dryer if necessary.

Initials

Enter the initials of the person performing the check in the far right column.

Chilled Water Temperature

Check the inlet condensing water temperature at Test Point 6 (refer to Figure 5-3 or Figure 5-4). The temperature should be between 40 °F (4 °C) and 90 °F (32 °C) and should not vary more than $\pm$10 °F ($\pm$6 °C) from its original temperature setting. The rate of temperature change of the inlet water should not be greater than 5 °F (3 °C) per 15-minute period.

The outlet water temperature is measured at Test Point 7 (refer to Figure 5-3 or Figure 5-4). If a gradual reduction in the temperature between inlet and outlet water occurs while the inlet temperature remains constant, the condenser may be contaminated. If a gradual increase in temperature is observed, the strainer may be clogged.

Chilled Water Pressure

Not all units have a gauge to measure the pressure of the inlet and outlet condensing water. A normal pressure differential is between 5psig and 20 psig.

Gallons Per Minute (GPM)

The amount of water flowing in the RCU is measured in GPM and is calculated in the following manner:

$$\frac{\text{BTU}}{\text{Difference in water temperature} \times 500.5} = \text{GPM}$$

The specifications for the amount of heat produced by your computer system can be obtained from HTS and is measured in British Thermal Units (BTU). The numeral 500.5 is a constant value. A low GPM is an indication of a cool water inlet temperature. A high GPM indicates a warm water inlet temperature.

Suction and Liquid-line Elements

During operation, the suction and liquid-line filter elements experience a small temperature drop. As debris is filtered out, the temperature drop increases. The temperature drop should be checked every 3 months. If the temperature difference exceeds 2 °F (1.2 °C) from the initial reading, the filters should be replaced.

Refrigerant

Periodic checks should be made on all connections and joints in the RCU. Visually inspect the connections for gross leaks of oil. Use a leak detector to verify suspected leaks.

Maintenance Procedures

This subsection provides information on the following RCU-1 and RCU-2 maintenance procedures:

- Evaporator adjustments
- Liquid-line filter replacement
- Adding compressor (refrigerant) oil
- Adding refrigerant
- Compressor replacement

Evaporator Adjustments

The evaporator pressure and superheat adjustments for the RCU-1 are performed at the HEU. The adjustments for the RCU-2 are made on the power supply cold plates and the cold bars of the IOS and SSD. The exact adjustments depend upon the type of equipment being cooled. For the adjustments specific to your site, contact HTS.

The following tools are required to make evaporator and superheat adjustments:

- Manifold gauge
- Fluke meter with temperature probe
- 5/16-in. (8 mm) ratchet mounted allen wrench
- Two box-end wrenches [1 1/8 and 1-in. (30 and 26 mm)]
- Refrigeration valve stem ratchet
- Cleaning rags

HEU Heat Exchange Subassembly and IOS and SSD Evaporators

Perform the following steps to adjust the evaporator pressure and superheat of the HEU heat exchange subassembly and IOS and SSD evaporators (power-supply cold plates and cold bar columns).

1. If adjusting the evaporator pressure and superheat of the IOS or SSD power-supply cold plates, turn off the mainframe power and remove the power-supply covers.

2. Power on the mainframe and allow the system to operate 2 to 4 hours before making any adjustments. Adjustments are made while the mainframe is running.

WARNING

Electrical shock hazard to humans and short circuit hazard to equipment. Avoid contact with voltages within the power supply area. Use caution when making adjustments to equipment.

3. Use a manifold gauge to measure the evaporator pressure.

WARNING

High pressure hazard. Before attaching a manifold gauge, turn the right and left handwheels clockwise to shut off the gauge and prevent pressurized Freon from escaping. Freon can cause skin irritation or blindness.

4. Connect the blue hose of the manifold gauge to the Schrader valve of the EPR valve.

5. Read the evaporator pressure on the blue gauge of the manifold gauge. A normal pressure is within the range of 90 psig to 95 psig. If the pressure is not within this range, the EPR valve must be adjusted.

6. To adjust the EPR valve, remove the protective cap from the EPR valve. Use the 5/16-in. (8 mm) allen wrench to make the following adjustments:

   a. If the pressure is too high, turn the manual adjustment counterclockwise. Make all adjustments in 1/4 turn increments.

   b. Wait 10 minutes and observe the pressure drop on the manifold gauge. If further adjustment is needed, make another 1/4 turn. Wait 5 to 10 minutes before making additional adjustments.

   c. If the pressure is too low, turn the manual adjustment clockwise in 1/4 turn increments.

   d. Wait 10 minutes and observe the pressure rise on the manifold gauge. If further adjustment is needed, make another 1/4 turn. Wait 5 to 10 minutes before making additional adjustments.

7. To perform the superheat adjustment, refer to Table 4-1 and note the saturation temperature that corresponds with the measured evaporator pressure.

8. Use the temperature probe to measure the temperature of the evaporator just past the expansion valve's remote temperature sensing bulb.

9. Subtract the saturation temperature from the measured evaporator temperature to find the system superheat. The superheat for the various systems should be as follows: HEU heat exchange subassembly, between 5 °F and 10 °F (3 °C and 6 °C); IOS/SSD power supply cold plate, between 8 °F and 14 °F (5 °C and 8 °C); and IOS/SSD cold bar, between 6 °F and 10 °F (4 °C and 6 °C). If the superheat is not within the specified range, the expansion valve must be adjusted.

10. To adjust the expansion valve, remove the protective cap covering the adjusting screw using the box wrenches. Be careful not to loosen the expansion valve packing nut in order to prevent a Freon leak. Use the refrigeration valve stem ratchet to make the following adjustments:

CAUTION

Hazard to equipment. Electrical shorts may occur when adjusting the expansion valve in the power supply area of the IOS or SSD. Avoid contact with the suppressor plate of the power supply. Damage to the mainframe may result.

a. If the superheat is too high, turn the expansion valve adjusting screw counterclockwise 1/4 turn. Make all adjustments in 1/4 turn increments.

b. Wait 5 to 10 minutes and measure the evaporator temperature again. If further adjustment is needed, make another 1/4 turn. Wait 5 to 10 minutes before making further adjustments.

c. If the superheat is too low, turn the expansion valve adjusting screw clockwise 1/4 turn. Make all adjustments in 1/4 turn increments .

d. Wait 5 to 10 minutes and measure the evaporator temperature again. If further adjustment is needed, make another 1/4 turn. Wait 5 to 10 minutes before making further adjustments.

11. After the superheat is properly adjusted, wait 15 minutes and measure the evaporator pressure again. The temperature should not fluctuate more than 2 °F to 3 °F (1.2 °C to 1.8 °C) during a 5 minute period.

12. Replace the expansion valve protective cap.

13. Place the center (white) hose of the manifold gauge in a towel. Open the left handwheel slightly to release some pressure and then disconnect the blue hose from the EPR valve.

14. Replace the caps on the EPR valve.

15. Wait 5 to 10 minutes to allow the refrigerant that might have escaped to dissipate. Set the leak detector to medium sensitivity and check for refrigerant leaks around the expansion valve.

Liquid-line Filter Replacement

The following tools are needed to replace the liquid-line filters:

- Vacuum pump
- 1/2-in. (13 mm) socket on ratchet
- Manifold gauge
- Screwdriver
- Aero Quip adapter
- Replacement filter (4 replacement filters are used with the RCU-1)
- Valve stem ratchet
- Heat gun
- Crescent wrench

- Towels
- Fast Charger

The liquid-line filter replacement procedure is approximately the same for both the RCU-1 and the RCU-2. Perform the following steps to replace the liquid line filter(s) (refer to Figure 5-5).

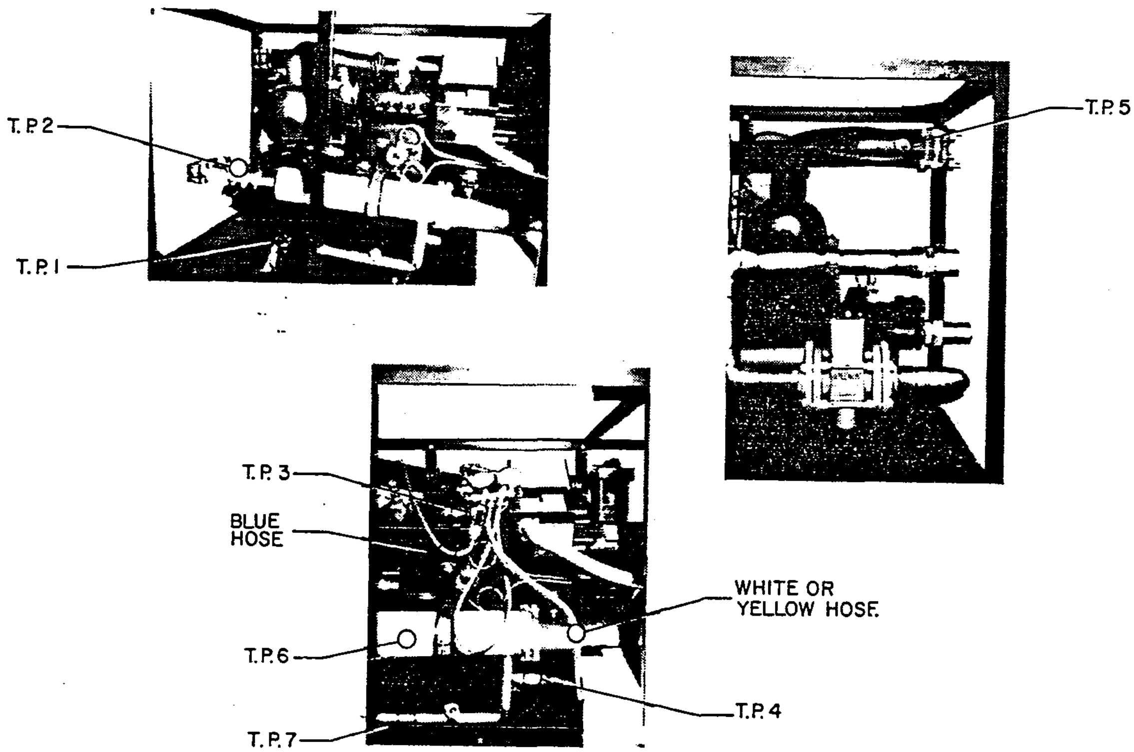

Figure 5-5. Liquid Line Filter Replacement

1. Close the liquid line black service valve (T.P.1) located on the bottom of the receiver while the system is running. (The packing nut should be loosened one full turn before attempting to close the valve.)

2. After the system has powered down, shut off the suction service valve on the suction line and the discharge service valve on the liquid line. Bleed off any remaining pressure in the compressor and mainframe. (For the RCU-2, wait 5 minutes after the system has initially powered off and operate the solenoid cheater switch on the back of the PDU. Hold the switch until the compressor pumps again down and powers off. Repeat this step two more times.)

3. Remove the cap of the brass service valve (T.P.2) on the liquid line next to the filter. Loosen the packing nut and close the valve. The filter(s) are now closed between the two closed valves.

4. Connect a Fast Charger (T.P.3) between the blue gauge and blue hose of a manifold gauge.

WARNING

High pressure hazard. Before attaching a manifold gauge, turn the right and left handwheels clockwise to shut off the gauge and prevent pressurized Freon from escaping. Freon can cause skin irritation or blindness.

5. Bleed the manifold gauge hoses.
6. Attach the manifold gauge at the Aero Quip fitting near T.P. 2 between the liquid line (T.P. 4) and the suction line (T.P.5) of the RCU-1 compressor as shown in Figure 5-5. On the RCU-2 attach the manifold gauge between the liquid line (T.P. 4) and the suction line (T.P. 5). (Blue hose to suction line, and center, white hose to liquid line.) Ensure that the arrow on the Fast Charger points in the direction of the suction line.
7. Open the valve on the blue gauge side of the manifold gauge and note the pressure reading.
8. Using a heat gun (two if possible) apply heat to the liquid-line filter housing (T.P. 6) underneath the housing. After a short period of time, the compressor will start and then turn off. Keep heating the filter housing until the pressure on the manifold gauge is approximately equal to the suction pressure on the gauge panel.
9. Remove the heat from the liquid-line filter housing, and after a short time, feel the housing. If cold, reapply heat until the housing is approximately room temperature.
10. Repeat steps 7 and 8, except apply the heat to the piping near the sight glass (T.P.7).
11. When the pressures equalize, close the blue manifold gauge.
12. Remove the blue hose from the suction line adapter.
13. Slowly open the valve on the blue side of the manifold gauge and allow the hose to bleed until the gauge reads 0.
14. Repair or replace the liquid-line filter(s).
15. Remove the Fast Charger (T.P. 3) from the manifold gauge.
16. Disconnect the center hose from the manifold gauge and reattach it to the blue gauge side of the manifold gauge. The blue gauge should now connect with the liquid line.
17. Connect the vacuum pump to the center port of the manifold gauge.

18. Follow the directions on the vacuum pump. Start the pump and allow it to run for half an hour. Ensure that the service valves are tightly secured.

19. When the blue manifold gauge reads between 28 and 30 in. Hg, close the valve on the blue gauge.

20. Open both service valves. The pressure should be between 150 psig and 170 psig.

21. Remove the manifold gauge. Power on the system and check for leaks using a Freon leak detector.

Adding Compressor (Refrigerant) Oil

Oil can be added to the compressor while it is or is not running. The following tools are needed to add oil:

- Oil pump
- Towels
- 1 gal. of 3GS refrigerant oil

Perform the following steps when adding oil to the compressor.

> **WARNING**
>
> High pressure hazard. When adding oil, properly attach the refrigerant hose from the oil pump to the Schrader valve fitting on the crankcase access port as quickly as possible. Pressurized Freon is present and can escape, causing skin irritation or blindess.

1. Attach the oil pump to the container of oil.
2. Purge air from the pump by pumping oil into the the hose.
3. Remove the cap from the crankcase access port.
4. Attach the oil pump hose to the port. Some pressure will be released as the hose is connected.
5. Pump oil into the crankcase until the oil sight glass is half covered.
6. Remove the oil pump hose and replace the cap.
7. Clean the oil pump.

Adding Refrigerant

Adding refrigerant to the refrigeration system is done only while the mainframe is running. The following tools are needed to add refrigerant:

- Manifold gauge
- Canister of Freon R-22
- Aero Quip adapter
- Fast Charger
- Aero Quip wrench
- Fluke meter with temperature probe

If the system subcooling or the liquid-line sight glass indicates that refrigerant is needed, perform the following steps (system subcooling indicates a lack of refrigerant by a liquid-line temperature of more than 85 °F (12 °C); the liquid-line sight glass indicates a lack of refrigerant by bubbles or foaming):

1. Remove the suction line access port cap.

2. Attach the Aero Quip adapter to the access port and tighten with the Aero Quip wrench.

3. Connect the Fast Charger to the blue manifold gauge port and attach the blue hose to the Fast Charger. The arrow on the Fast Charger should point away from the manifold gauge. The Fast Charger is used to atomize the refrigerant liquid.

WARNING

High pressure hazard. Before attaching a manifold gauge, turn the right and left handwheels clockwise to shut off the gauge and prevent pressurized Freonfrom escaping. Freon can cause skin irritation or blindness.

4. Connect the white (center) hose to the refrigerant canister.

5. Set the selector on the canister valve stem to Liquid because a Fast Charger is being used.

CAUTION

Hazard to equipment. If a Fast Charger is not being used to add refrigerant, set the selector on the Freon canister valve stem to Vapor to prevent slugging the compressor. Slugging, caused by liquid refrigerant entering the compressor, can cause broken discharge valve plates and broken connecting rods. It can also result in poor lubrication and subsequent bearing wear.

6. Open the canister valve and allow the air to be purged from the hoses while connecting the blue hose to the Aero Quip adapter.

7. Regulate the flow of refrigerant by adjusting the manifold gauge valve. The pressure on the gauge should be slightly higher than the suction pressure of the system.

8. Add refrigerant until the liquid-line temperature is between 80 °F and 85 °F (27 °C and 29 °C). Allow half an hour for the system to stabilize and recheck the temperature. Add more refrigerant if necessary.

9. Close the refrigerant canister valve.

10. Close the manifold gauge valve.

11. Disconnect the blue hose from the Aero Quip adapter.

12. Remove the Aero Quip adapter and replace the access port cap.

Compressor Replacement

If a compressor is frozen or knocks excessively, it needs to be replaced. The following tools and equipment are required to replace the compressor:

- Manifold gauge
- Refrigerant oil,
- Vacuum pump
- Gasket kit
- Oil pump
- Teflon plumber's tape
- Torque wrench (20 to 40 ft-lb)
- Towels
- Hoist
- Shallow container
- Freon R-22
- Eye-bolts
- Replacement compressor
- Fluke meter

To replace the compressor, perform the following steps.

WARNING

High pressure hazard. Before changing a compressor, pump the computer system's Freon into the condenser/receiver. Pressurized Freon that escapes from refrigerant hoses can cause skin irritation or blindness.

1. Close the suction service valve.

2. Check the suction pressure. If it is greater than 5 psig, pump down the system until 1 or 2 psig of suction pressure is reached.

3. Remove the hi-lo control box of the functioning compressor and jumper the two connectors that have numbered wires connected to them to pump down the system.

4. When the suction pressure drops to 1 or 2 psig, remove the jumper and close the discharge service valves on both compressors.

5. Shut off the electrical power to the compressor; verify that there no longer is any electrical power with a meter.

6. Tag and disconnect all sensor and plumbing connections from the bad compressor. At this time the refrigerant left in the system will escape.

7. Tag and disconnect the electrical connections on the bad compressor.

8. Disconnect the three power connections at the compressor's junction box, remove the bolts holding the junction box to the compressor, and move the junction box and cabling out of the way.

9. The control module of the replacement compressor must have the same manufacturer and voltage rating as the faulty compressor; if it differs, replace the control module in the junction box with the one from the replacement compressor.

10. Remove the nuts holding the faulty compressor.

11. Remove the four mounting bolts of the faulty compressor.

12. Loosen the mounting bolts of the replacement compressor.

13. Attach the hoist to the faulty compressor and move it away from the suction housing until the studs are out of the mounting holes (refrigerant oil will leak) .

    Ensure that the sensors, cables, and plumbing are not damaged when the compressor is removed.

14. Lift the compressor clear of the RCU and place it in an open area.

15. Remove the fittings that are not included with the replacement unit from the faulty compressor.

16. Ensure that all surfaces are cleaned of old gasket material and install new gaskets on the fittings of the replacement compressor. Coat the gaskets with refrigerant oil to ensure a good seal.

17. If a compressor head has been changed, torque the head bolts to 32 ft-lb, tightening in a star pattern.

18. Hoist the new compressor into the refrigeration unit. Align the mounting studs and slide the compressor into place.

19. Re-connect all bolts, sensors, electrical, and plumbing connections.

20. Attach the white (center) hose of the manifold gauge to the vacuum pump and the blue hose to the fitting on the discharge service valve. Connect the red hose of the manifold gauge to the crankcase access port.

WARNING

High pressure hazard. Before attaching a manifold gauge, turn the right and left handwheels clockwise to shut off the gauge and prevent pressurized Freon from escaping. Freon can cause skin irritation or blindness.

21. Open both valves of the manifold gauge and turn on the vacuum pump. Allow the vacuum pump to operate for two hours.

22. Close the valves on the manifold gauge and turn off the pump. Monitor the blue manifold gauge to insure that the compressor holds a vacuum for 15 to 20 minutes.

23. Open the suction service valve and the two discharge service valves.

24. Disconnect the center hose from the vacuum pump and the red hose from the crankcase access port.

25. Open the valves on the manifold gauge to release pressure in the hose and remove the blue hose from the discharge service valve.

26. Add oil to the compressor.

27. For system checkout, refer to the appropriate CRI Engineering Specification:

    - *#02254500; RCU-1 Condensing Unit Installation Specification*
    - *#02253700; RCU-2 Condensing Unit Installation Specification*

RCU TROUBLESHOOTING

Table 5-1 is a troubleshooting guide for RCU-1 and RCU-2. The table lists problems, causes, symptoms, and corrective action.

Table 5-1. RCU Troubleshooting

Problem	Cause	Symptoms	Corrective Action
Compressor will not start	Oil control has failed	Will start by resetting	Check oil level, oil pressure and the control.
	High-pressure control has failed	Open contacts on control, gauge pressure above 275 psig	Reset control when pressure drops and check: a. Water supply b. Water valve operation c. Water strainer (plugged) d. Condenser tube fouling e. Refrigerant overcharge f. Nonconensibles (purge)
	Suction pressure too low for suction control	Low suction gauge pressure and open control contacts	Check for solenoid valve opening on computer. Check control setting and operation.
	Open thermal overload	Hot compressor, no power to starter coil	Allow compressor to cool down. Check suction temperature and pressure and current draw after start.
	Inoperative motor starter	Test for burned-out coil and broken or burned contacts.	Repair or replace coil or contacts.
	Power failure	No power on line side of starter	Check for breaker trip or broken lead.
	Low voltage	Low voltage on side of starter	Check power at breaker bus, call power company.
	Power phase load	No voltage on one leg of line side of starter	Check power at breaker bus, call power company.
	Frozen compressor or burnt motor	Compressor receives power and draws current; breaker will drop power	Replace compressor or RCU.

Table 5-1. RCU Troubleshooting (continued)

Problem	Cause	Symptoms	Corrective Action
Compressor short-cycle	Intermittent contact in control circuit	Normal operation except unexplained stopping	Replace faulty control.
	Low-pressure control	Normal operation except unexplained stopping	Set differential in accordance with conditions.
	Leaky solenoid valve	Short-cycle only during off periods	Find faulty valve and repair.
	Low refrigerant charge	Stops on low-pressure control, gauge pressure is low, bubbles appear, or partially filled liquid-line sight glass.	Repair lead and add charge.
	Restricted suction-line filter	Considerably cooler outlet temperature on filter	Repair filters.
	Restricted line filter dryer	Frosting beyond outlet of dryer	Replace dryers.
	Broken or leaky discharge valves	Fast rise in suction pressure	Replace valve plate(s).
Compressor will not shut-down	Welded starter contacts or faulty low pressure control	Zero or below suction gauge pressure	Replace starter contacts or control.
	Solenoid valve(s) open	Suction pressure remains above cut-out pressure	Check operation of solenoid valve relay in power cabinet.

Table 5-1. RCU Troubleshooting (continued)

Problem	Cause	Symptoms	Corrective Action
Compressor loses oil	Suction line traps oil	Oil level gradually drops.	Repitch lines to provide proper slope back to compressor, and provide lift loops.
	Velocity is too low in risers	Oil level gradually drops.	Resize vertical lines.
	Clogged suction-line filter	Oil level gradually drops.	Repair or replace filters.
	Loose or incorrectly mounted expansion valve bulb	Excessively cold suction line	Properly install bulb.
	Leaking crankcase fittings	Oil around compressor base	Repair leak.
Compressor is noisy	Lack of oil	Compressor cuts out on oil control	Add oil.
	Internal compressor broken or faulty	Compressor knocks	Replace compressor.
	Liquid “flood back” (liquid Freon in compressor)	Excessively cold suction line	Properly install expansion valve bulb, repair stuck open expansion valve
	Water pressure is too high or intermittent water pressure occurs	Water valve hammers or chatters	Install air chamber before valve.

Table 5-1. RCU Troubleshooting (continued)

Problem	Cause	Symptoms	Corrective Action
Discharge pressure too high	Too little or too warm condenser water or plugged strainer	Excessively warm water leaving condenser	Provide proper water supply, adjust water valve, and clean strainer
	Fouled condenser tubes	Excessively cool water leaving condenser	Clear condenser tubes
	Air or noncondensible gas in condenser	Exceptionally hot condenser temperature; pressure is higher than it should be	Purge condenser
	Refrigerant overcharge	Exceptionally hot condenser	Remove excess refrigerant or purge
Discharge pressure too low	Too much condenser	Cold water leaving condenser	Adjust water valve
	Lack of refrigerant	Bubbles in sight glass	Locate and repair leak and discharge
	Broken or leaky compressor discharge valves	Suction pressure rises faster than 5 psig/min. after shut-down	Replace valve plate(s)
Suction pressure too high	Overfeeding expansion valves	Abnormally cold suction line	Properly install expansion valve bulb.
	Broken suction valves in compressor	Compressor clatters	Replace valve plate(s).
Suction pressure too low	Lack of refrigerant	Bubbles in liquid-line sight glass	Locate and repair leak and charge RCU.
	Clogged liquid-line dryer or suction-line filter	Temperature change across dryer or suction-line filter	Replace liquid-line filter elements.

Table 5-1. RCU Troubleshooting (continued)

Problem	Cause	Symptoms	Corrective Action
High cold bar temperature	Obstructed expansion valve	Loss of capacity at warm outlet tube	Clean valve or replace.
	Expansion valve power head assembly lost charge	No refrigerant flow through valve	Replace power head assembly.
	Cold bar is "oil bound" (excess oil restricts flow through cold bar)	Cool expansion valve outlet but abnormally warm cold bar outlet tube	Open evaporator pressure to maximum for several minute and reset.
	Low refrigerant charge	Hissing at expansion valve-warm outlet tube	Repair leak and/or add charge.
	EPR valve incorrectly set	Warm Freon vapor entering valve and cold Freon vapor leaving valve	Reset valve.
Low cold bar temperature	EPR valve incorrectly set	Abnormally cool bar outlet tube	Reset valve.
Abnormally cold suction line	Overfeed of expansion valve	Cold suction line or cold suction line manifold	Check expansion valve bulb attachment and/or adjust superheat setting.
	Expansion valve stuck open	Cold suction line or cold suction line downstream of EPR valve	Cycle superheat setting to fully open and back to original setting. Open valve and inspect for foreign matter.

Table 5-1. RCU Troubleshooting (continued)

Problem	Cause	Symptoms	Corrective Action
System short of capacity	Capacity control incorrectly set	Power to capacity control solenoid	Adjust control.
	Flash gas in liquid line	Liquid-line sight glass has bubbles or is partially full and/or the expansion valve hisses	Add refrigerant.
	Clogged filter or dryer	Considerably cooler outlet temperature on filter; frosting beyond outlet of dryer	Repair filters or replace dryers.

MGS MAINTENANCE

This section provides information for maintaining the Motor Generator Set (MGS). The adjustment procedure for the MGS overvoltage protection circuitry is described.

MGS Overvoltage Adjustment Procedure

This procedure enables the system overvoltage protection circuitry provided by the MGS. It allows the field engineer (FE) to adjust the proper trip voltage on the MGS NORMAL and OVERVOLTAGE TRIP RESET (OTR) breakers.

The benefits of this procedure include fewer trips for the FE between the MGS and the CRAY Y-MP mainframe control system console. This procedure also eliminates the multiple system cycles previously necessary to ensure that the circuit breakers trip when voltage to the mainframe reaches its threshold.

The following circuit breakers are found in the generator half of the MGS cabinet (refer to Figure 5-6):

- NORMAL circuit breaker
- OVERVOLTAGE TRIP RESET (OTR) circuit breaker

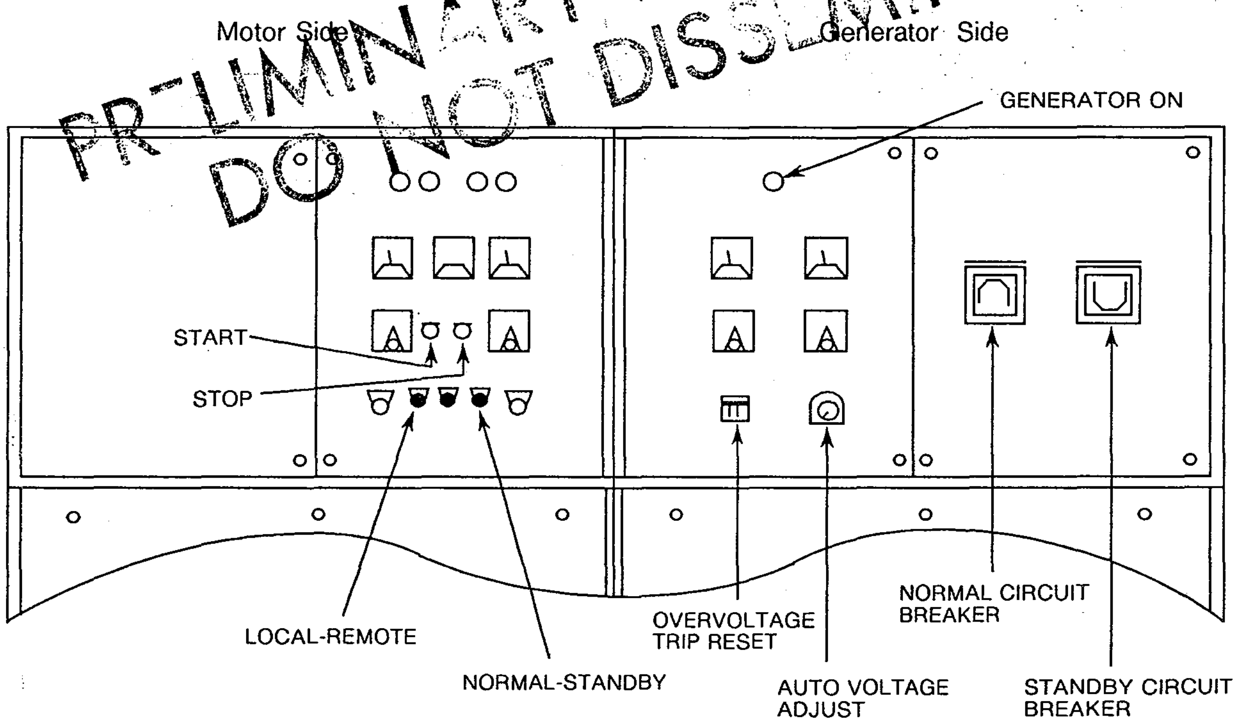

Figure 5-6. MG Cabinet

Tools

Two FEs must be present when certain portions of the MGS overvoltage adjustment procedure are performed, for example, Step 11 and similar steps in the NORMAL and OTR Circuit Breaker Trip Voltage Verification subsections. The following tools are also necessary:

- Potentiometer adjustment tool
- Hex screwdriver handle set
- Digital voltmeter
- Flashlight
- Paper and pencil

The following is the step-by-step procedure for performing the MGS overvoltage adjustment procedure:

1. With the CRAY Y-MP computer system powered up, press the MG scanner control switch to observe the 400-Hz output voltage of the MGS. Make any adjustments at the MG Adjust switch to assure a 208-Vac output.

2. Press the Volt. scanner control switch to observe the output of the -5.2 Vdc, -4.5 Vdc, and -2.0 Vdc power supplies. Make any necessary adjustments at the voltage adjust and circuit breaker panel to ensure the output voltage of the power supplies is as close to -5.2 Vdc, -4.5 Vdc, and -2.0 Vdc as possible.

3. Take a voltage reading of the NORMAL circuit breaker with the digital voltmeter across wires T1 and T2 (refer to Figure 5-7).

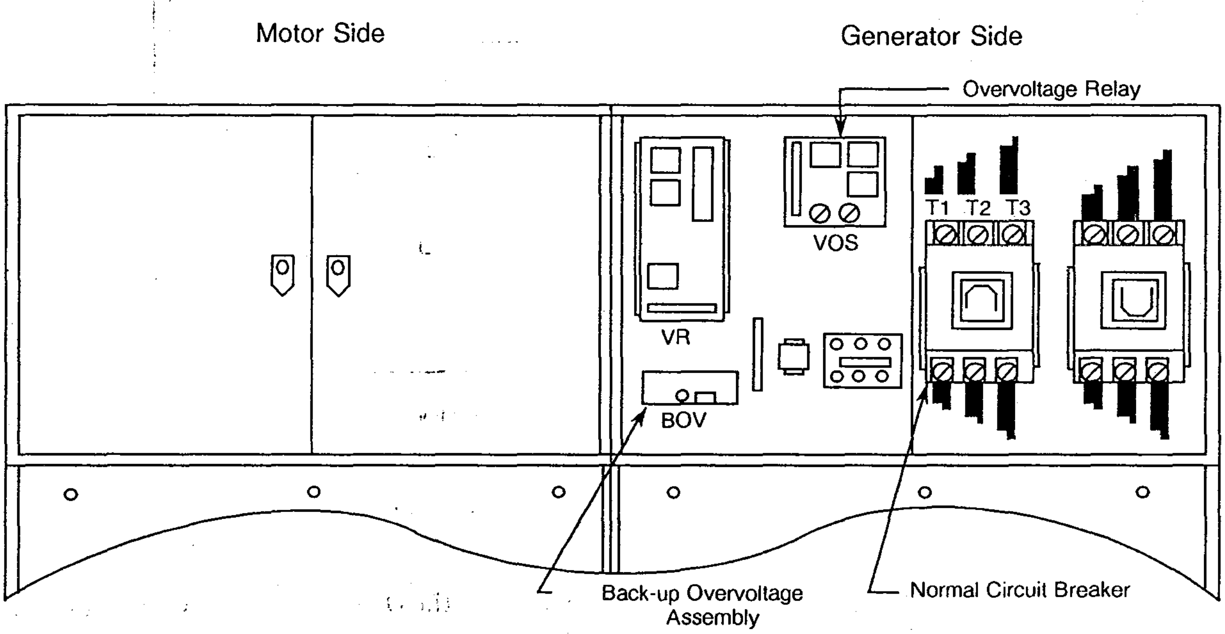

Figure 5-7. MG Cabinet (Internal View)

4. Calculate the voltage at which the NORMAL and OTR circuit breakers should trip. See the following example:

Assume that the voltage reading on the NORMAL circuit breaker was 214 Vac. The following are the formulas to use for the NORMAL and OTR breakers to estimate trip voltages:

- Output voltage + 6% = NORMAL circuit breaker trip voltage
- Output voltage + 5% = OTR circuit breaker trip voltage

If the output voltage is 214 Vac, calculate the trip voltages for the NORMAL and OTR circuit breakers to receive the following result:

214 Vac + 6% = 227 Vac (NORMAL circuit breaker trip voltage)
214 Vac + 5% = 225 Vac (OTR circuit breaker trip voltage)

5. Return to the CRAY Y-MP control system console and power off the mainframe.

6. At the motor side of the MGS cabinet, place the MGS in local mode by turning the LOCAL-REMOTE switch to LOCAL and the NORMAL-STANDBY switch to STANDBY.

7. At the generator side of the cabinet, trip the NORMAL circuit breaker.

8. Turn the potentiometer on the Back-up Overvoltage assembly clockwise (refer to Figure 5-8).

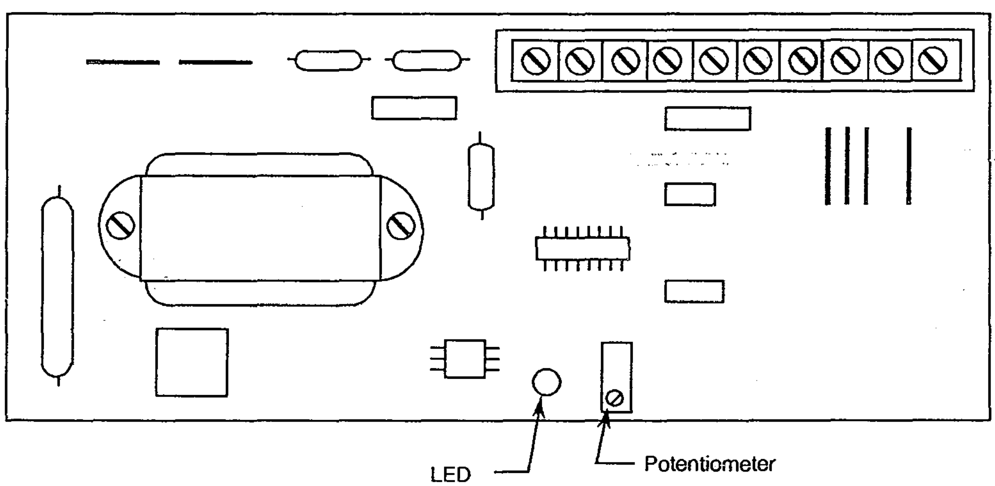

Figure 5-8. Back-up Overvoltage Assembly

9. Turn the Range Adjust potentiometer on the Overvoltage Relay (refer to Figure 5-9) clockwise completely.

10. Power up the MGS by pressing the START switch.

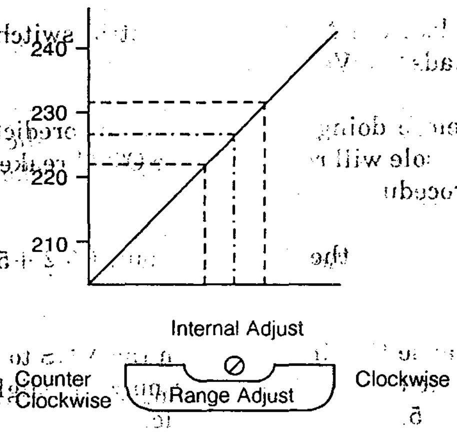

Figure 5-10. Range Adjust Window

NOTE: If the the OTR breaker does trip, go to Step 3. If the OTR breaker does not trip, start again from Step 2e.

3. Turn the AUTO VOLTAGE ADJUST switch counter-clockwise completely.

4. Reset the OTR circuit breaker.

OTR Circuit Breaker Trip Voltage Verification

1. To ensure that the OTR circuit breaker trips at the proper voltage perform the following steps:

   a. Measure T1 and T2 on the NORMAL circuit breaker and slowly turn the AUTO VOLTAGE ADJUST switch clockwise until reaching the calculated trip voltage. The OTR circuit breaker should again trip.

   b. Turn the AUTO VOLTAGE ADJUST switch counter-clockwise completely.

   c. Reset the OTR circuit breaker.

2. After verifying the trip voltage on the OTR breaker, return the MGS to the remote operating state by performing the following steps:

   a. Power down the MGS by pressing the STOP switch.

   b. Set the NORMAL circuit breaker.

   c. Turn the LOCAL-REMOTE switch to REMOTE and the NORMAL-STANDBY switch to NORMAL. At this time the MGS should power up.

3. Return to the CRAY Y-MP mainframe and power up the computer system by pressing the Start switch on the control system console.

4. Select the MG scanner control switch and ensure that the indicator panel reads 208 Vac, 400 Hz.

5. Before doing a reliability test, predict what DC voltage the control system console will read when the OTR breaker on the MGS trips, using the following procedure:

   Add 5% to the -5.2 Vdc output. (-5.2 + 5% = -5.46 Vdc)

NOTE: Because the line drop from the MGS to the mainframe control system console varies from site to site, the breaker may trip slightly before or after -5.46 Vdc. A range of -5.45 Vdc to -5.50 Vdc is acceptable.

6. Now, slowly increase the voltage to the mainframe using the MG Adjust potentiometer and observe the output voltage for the -5.2 Vdc power supply on the mainframe control system console. Ensure that the OTR breaker on the MGS cabinet trips when the voltage is still within the tolerance range.

7. If the voltage has been increased to -5.50 Vdc and the OTR circuit breaker has not tripped, do not increase the voltage any further. Instead, decrease the voltage to -5.2 Vdc. Next, check for incorrect trip voltage calculations and review the procedure to ensure no step was overlooked.

8. If the procedure is successful and the mainframe's power was shut off, press the Stop switch on the mainframe control system console.

9. Turn the MG Adjust potentiometer on the console slightly counter-clockwise.

10. Reset the OTR circuit breaker at the MGS.

NOTE: The MGS motor should still be spinning at operating speed, but the exciter field should not be on.

11. Return to the mainframe control system console and power up the mainframe.

12. Adjust the MG Adjust potentiometer to 208 Vac; adjust the variable transformers, if necessary.