ECN 75479

W.O. 7038-1085-72

DATE June 16, 1972

O&M CRITERIA SHEET

TM4-151-39
Volume II of III
Maintenance Manual

The following criteria are recommended:

Table 1-1, page 1-9. Add the following information as the first entry of the table:

INDICATOR	CONTROL	FUNCTION	LOCATION
	Switch, COARSE SPEED ENABLE	Provides increased speed of bridge while operating inside slowdown limits	Panel A

TM4-151-39

JOHN F. KENNEDY
SPACE CENTER

TECHNICAL MANUAL

APOLLO/SATURN

LAUNCH COMPLEX 39

MAINTENANCE MANUAL

175-TON BRIDGE CRANE

VOLUME II OF III

KSC FORM 16-12 (4/66)

TM4-151-39

TECHNICAL MANUAL

APOLLO/SATURN

LAUNCH COMPLEX 39

MAINTENANCE MANUAL

175-TON BRIDGE CRANE

VOLUME II OF III

CHANGE NOTICE

LATEST CHANGED PAGES SUPERSEDE THE SAME PAGES OF PREVIOUS DATE

Insert changed pages into basic publication. Destroy superseded pages.

1 SEPTEMBER 1965

CHANGED 22 NOVEMBER 1971

FOREWORD

The drawings contained in this volume reflect system modifications at the date of issue. Refer to the current drawing revisions for the latest system configuration.

See Operating Instructions, Volume II, for a cross reference of drawing numbers versus figure numbers.

TABLE OF CONTENTS

		Page
INTRODUCTION		
SECTION I EQUIPMENT LOCATION AND DESCRIPTION		1-1
1.1 GENERAL		1-1
1.2 MAJOR ELECTRICAL COMPONENTS		1-1
1.2.1	Power Source Equipment	1-1
1.2.2	Motor Control Center	1-2
1.2.3	Motor-Generator Sets	1-2
1.2.4	DC Drive Motors	1-3
1.2.5	Blower Motors	1-4
1.2.6	Metadyne	1-4
1.2.7	Control System	1-4
1.2.8	Cab Control Console	1-7
1.2.9 (Deleted)		
1.2.10	Electrical Protective System	1-8
1.3 through 1.5 (Deleted)		
SECTION II TEST EQUIPMENT AND SPECIAL TOOLS (Deleted)		
SECTION III PREVENTIVE MAINTENANCE		3-1
3.1 GENERAL		3-1
3.2 PREVENTIVE MAINTENANCE INTERVALS		3-1
3.3 PREVENTIVE MAINTENANCE PROCEDURE		3-1
3.3.1	Crane Exercising	3-1
3.3.2	Preventive Maintenance	3-1
3.3.3	Inspection Notes	3-5
SECTION IV TROUBLESHOOTING		4-1
4.1 GENERAL		4-1
4.2 TROUBLESHOOTING CHART		4-2
SECTION V MAINTENANCE		5-1
5.1 GENERAL		5-1
5.2 CLEANING		5-1
5.2.1	Dirt and Grease	5-1
5.2.2	Oxidation	5-1
5.2.3	Pitting	5-1
5.3 through 5.6.2 (Deleted)		

5.7 CONTROL SYSTEM POWER 5-2
5.7.1 General 5-2
5.7.2 Transformers 5-2
5.7.3 Power Supplies 5-2

5.8 SINGLE-MOTOR OPERATION 5-3
5.8.1 General 5-3
5.8.2 Single-motor Setup 5-3

SECTION VI (Deleted)

APPENDIX A (Deleted)

APPENDIX B MAINTENANCE AND REPAIR PARTS DATA

LIST OF ILLUSTRATIONS

175-Ton Bridge Crane, Elevation vii

175-Ton Bridge Crane, Plan View viii

Figure 1-1 Closed-Loop/ Open Loop Control Systems 1-5

Figure 1-2 (Deleted)

Figure 4-1 (Deleted)

LIST OF TABLES

Table 1-1, Function and Location of Controls and Indicators Mounted In Cab Control Console. 1-9

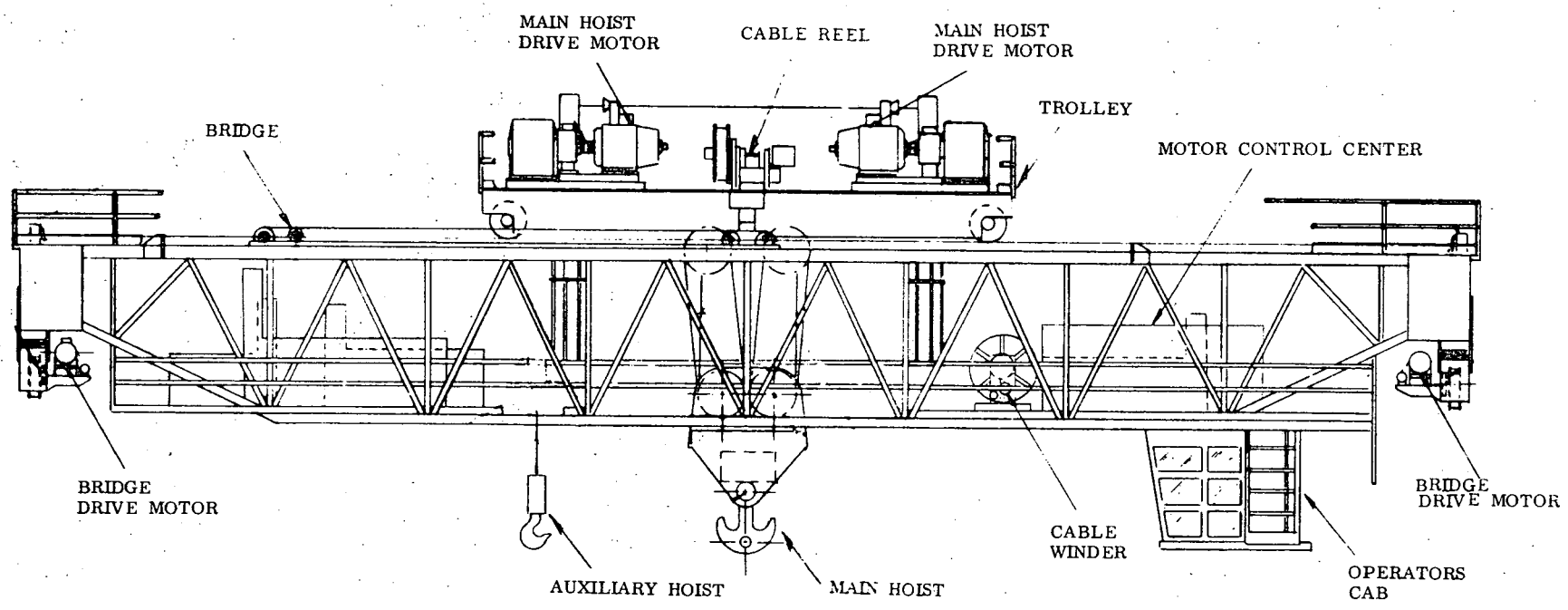
Table 1-2 (Deleted)

Table 1-3 (Deleted)

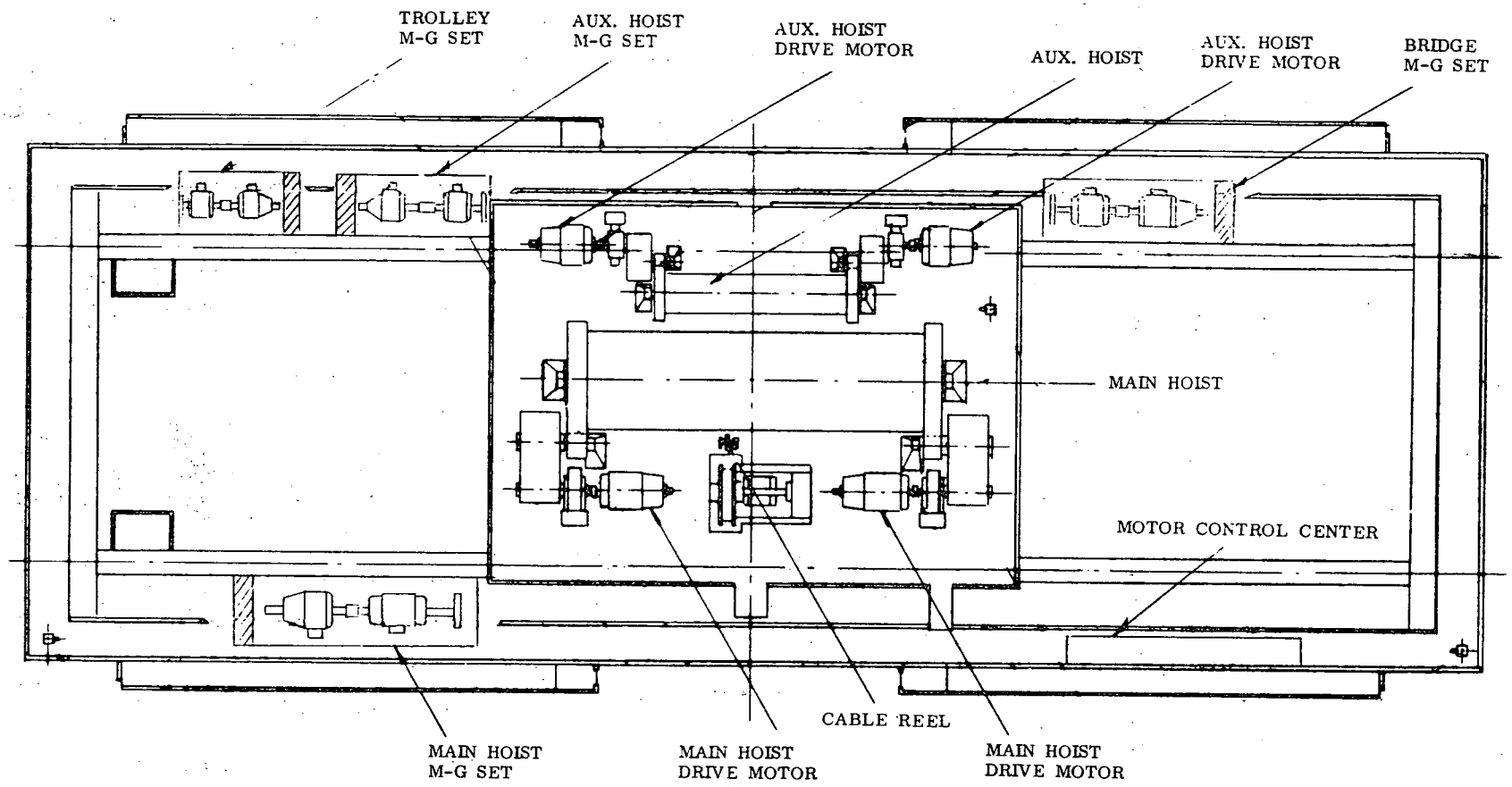
Pages iv through v Deleted

INTRODUCTION

This manual contains maintenance instruction and information for the electrical system of the 175-ton bridge crane installed in the Vehicle Assembly Building (VAB) at Launch Complex 39, Merritt Island, Florida. The instructions contain a brief description of function, location, and operation of the major electrical components; list of maintenance equipment such as special tools and test equipment; preventive maintenance procedures; maintenance instructions for peculiar equipment; and, an appendix of vendor information pertinent to components. Illustrations and tables are provided to simplify explanation and indicate location of electrical components and to generally assist maintenance personnel in the performance of maintenance procedures.



175 TON BRIDGE CRANE , ELEVATION



175 TON BRIDGE CRANE , PLAN

SECTION I

EQUIPMENT LOCATION AND DESCRIPTION

1.1 GENERAL

The 175-ton electric bridge crane has a main hook load capacity of 175 tons and an auxiliary hook capacity of 25 tons. It was specifically designed for assembly, sub-assembly, and handling operations required on space vehicles in the Vehicle Assembly Building. The crane operates on rails which are 169 feet above floor level and extend through both the low and high bay areas; crossing at right angles beneath the 250 ton crane which is in the high bay area.

Operating controls for the crane are located on the Main Control Console in the operator's cab, which is slung beneath the bridge. Controls are provided for hoisting and lowering the main and auxiliary load hooks, traverse of the bridge along the craneway, transverse movement of the trolley across the bridge, and main hook swiveling.

Access for maintenance is provided by walkways and ladders. A lower walkway provides access to the Motor Control Center (MCC) and to the motor-generator sets for the various motions. The upper walkway parallels the trolley rails and is used in trolley maintenance and inspection. Ladders join the upper and lower walkway and provide access to the control cab beneath the bridge.

1.2 MAJOR ELECTRICAL COMPONENTS

Major electrical components of the crane are the power source equipment, motor control center, motor-generator sets, dc drive motors, blower motors, metadyne, control system cab control console, and the electrical protective system.

1.2.1 Power Source Equipment. The main electrical source for crane power, lighting, and controls is taken from the building source which is 480-volts, 3-phase, 60-cycles. KSC drawing 67-K-L-11348 has a simplified schematic of the basic power distribution to the equipment. Feeder shoes on the crane connect the main line (building source) to the main circuit breakers on the crane adjacent to the MCC (see KSC drawing 67-K-L-11348 and Colby drawing D-28690).

Power for lighting at 120 volts, 60 cycles, is supplied by a 9-KVA, 3-phase transformer located in the lighting transfer panel of the MCC.

Transfer of power from the bridge to the trolley of the crane is made possible by use of a Gleason Reel Corporations No. 222 Powertrak as shown on Colby dwg. D-28679.

Principal users of electrical power are the motor-generator sets of the main hoist, auxiliary hoist, bridge drive, and the trolley drive. Other power requirements include the main hook swivel motor, main hook cable reel, remote console cable reel, motor blowers, and lighting.

1.2.2 Motor Control Center. The MCC located on the lower bridge structure walkway, contains the various circuit breakers, motor starters, relays, transformers, and timers which control the starting and stopping of the motor-generator sets, the cable winder motor, overload relays to protect the motor circuits, the 9 KVA lighting transformer, and the phase failure transformers and relays.

1.2.3 Motor-Generator Sets. Four motor-generator sets, one for each crane motion, convert the 480-volt, 3-phase, 60-cycle building power supply to dc voltage required to power the drive motors of each motion. Each motor-generator set consists of a constant speed ac motor mechanically connected (in-line shaft coupling) to a shunt wound generator. The output voltage (dc) and direction of rotation is controlled by changing the voltage or polarity of the voltage to the shunt field of the dc generator either by manual manipulation of the controls or by the motor control feedback system, which uses the dc drive motor voltage and current as a reference. For additional details on controls system operation, refer to paragraph 1.2.7.

The ac drive motor of the motor-generator set is a 480-volt, 3-phase, 60-cycle, 1750-RPM, low-slip, squirrel cage motor. Ratings of the various motor-generator sets are:

a. Main hoist . . . . . 300 HP
b. Auxiliary hoist . . . . . 150 HP
c. Bridge drive . . . . . 125 HP
d. Trolley drive . . . . . 30 HP

The dc generator of each set is a 480-volt dc, shunt wound device with fields rated at 80 volts dc. There is no series winding; the interpole or commutating winding is split and connected on each side of the armature.

A "klixon" overtemperature switch installed in the windings of the dc generator protects the generator against damage from overloading resulting in overheating. Upon sensing an overheating condition, the overtemperature switch will, by means of a control relay, shut down the motor-generator set and signal a warning to the operator by means of the overtemperature indicator lamp on the control console panel.

A rotary centrifugal switch on the generator shaft provides protection against overspeeding. The switch is factory set to trip at 2000 RPM. In case of motor overspeeding, the switch will trip and shut down operation of the motor-generator set and

extinguish the motor-generator ON light on the cab control console. Before operation can be resumed, the overspeed switch must be manually reset. Repeated tripping indicates a malfunction which must be corrected. The overspeed switch could possibly trip if the ac motor single-phased when handling a heavy overhauling load on the main or auxiliary hoist. A tachometer-generator located on the dc drivemotor (main and auxiliary hoists) provides additional overspeed protection. This protection is relay operated with automatic reset.

A power loss relay (IBR) in the motor-generator set control circuit is held closed whenever power is ON to the set. Upon loss of ac power, this relay opens and allows springs to immediately set the brakes to halt all motion until power is restored.

The drive control panel contains circuit breakers, relays, transformers, power supply, control system amplifiers, and the Metadyne unit which make up the control system for the motor-generator set. Those control items not included in the drive control panel are the manual speed/direction control in the operator's cab and the tachometer generator located at the dc drive motors.

Ventilation and cooling of components in the drive control panel and the motor-generator set enclosure is provided by a fan on the outboard end of the ac motor. This fan draws air through the motor-generator and forces it outward through the drive control panel enclosure.

1.2.4 DC Drive Motors. The dc drive motors are dc shunt-wound for 240 volts with 80-volt dc fields. They are designed to operate with their armatures in series with the 480-volt dc generator, of the motor-generator set, and their fields in parallel at 80 volts. Base speed of the hoist motors is 500 RPM with up to 1500 RPM with no load. The bridge and trolley drive motors base speed is 1150 RPM. Interpole commutating windings are split.

Each drive motor is protected against overloading (overheating) by two precision thermistors which are inserted into the field winding to detect overtemperature conditions. The thermistors (two are used to assure reliability) are connected to the factory set overtemperature relays (K1 thru K8) in the cab control console. Upon sensing an overheating condition the thermistor actuates the relay (K1 thru K8) which breaks motor control circuit and shuts down operation. Operation cannot be resumed until the overheating condition has been corrected.

Operation of the drive system depends upon the basic characteristic of a shunt-wound dc motor to run at a constant speed, regardless of load, in proportion to the applied dc voltage. At 240 volts, the hoist motors will run at 500 RPM and the bridge and trolley motors at 1150 RPM. At 120 volts, one-half of rated voltage, these motors will run at one-half the base speed. For high speed no-load operation, the field voltage (normally at 80 volts) is reduced to one-fourth or 20 volts by a field weakening resistor (FWR). The net change in field, because of saturation, is one-third resulting in an increase in speed of three times that of the full field speed with the same armature voltage. Such high speed operation is possible only on the hoists. High speed operation is under the control of the crane operator and is possible only if the following conditions exist:

a. Hoist speed selector switch must be in HIGH SPEED position.

b. Master switch must be advanced to full UP or DOWN position (maximum power).

The field weakening relay (FW), and the field weakening resistor (FWR) are located in the drive control panel.

1.2.5 Blower Motors. Blower motors, for forced ventilation, are provided for all dc motors. The blower motors are 480/240-volt, 3-phase, 60-cycle ac motors designed for continuous service. The blowers are provided to prevent drive motors overheating under prolonged loaded low-speed operation or overload conditions such as single motor operation. The drive motors are oversized and could normally be operated without blowers.

Each blower motor is protected against overloading by an overload sensing coil (1MBOL) which breaks the circuit to the motor when an overload (overtemperature) condition exists. The overload relays which perform this function are located in the blower motor panel of the MCC.

1.2.6 Metadyne. Each of the motor-generator set generators is controlled by a Metadyne (rotating amplifier) which is a special form of dc generator. Physically, it is a two-bearing motor-generator set with a 480-volt ac motor section bolted to the dc generator section. Both sections are supported on a common base and both rotors utilize a single shaft.

Each Metadyne unit has three sets of control windings: a cross-field control winding, an ac hysteresis winding, and the output leads. Operation of the Metadyne is based on shorting one set of brushes (A3 and A4), at 90 degrees to the control winding, through a low resistance winding (S1-S2) and taking the output from the remaining pair (A1 and A2).

In this particular application, all three sets of control windings are operated in parallel giving faster response than if the windings were connected in series. The hysteresis winding is provided to minimize the reduction in sensitivity (gain) when operating with small input signals such as when floating or at very low speeds.

In operation, the Metadyne provides dc voltage to the field coil of the motor-generator set generator thus controlling the output voltage to the dc drive motors. The Metadyne in turn is controlled by a composite signal consisting of operator command, dc motor reference, magnetic circuit saturation levels (bias), and dc motor current limit signal. Refer to paragraph 1.2.7 for more detailed description of the control system.

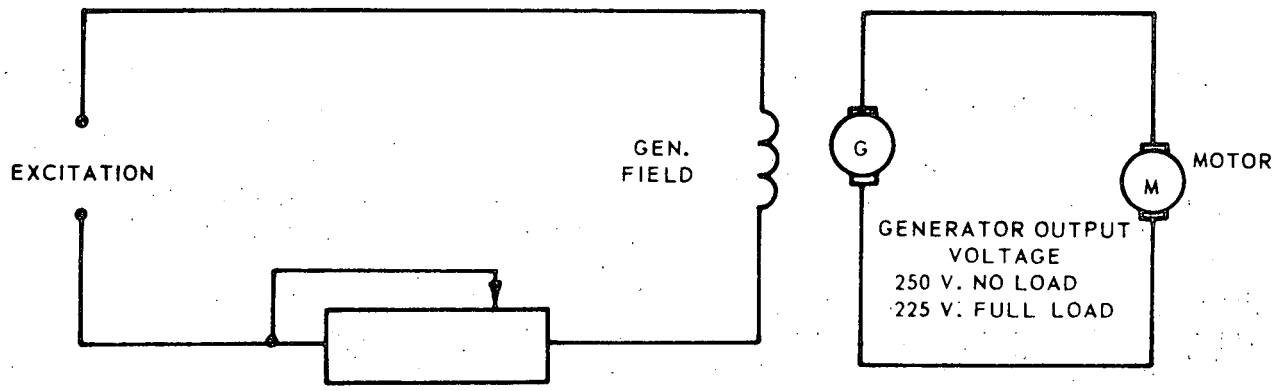
1.2.7 Control System. The control system for the motor-generator sets is complex. Some understanding of how the system functions is necessary for personnel performing maintenance functions.

Control systems may be of either the open-loop or closed-loop type. The open-loop system bases its control on some reference standard. A generator with its voltage controlled by means of a field rheostat is an example of a simple open-loop system. The reference standard is the position of the field rheostat. This type of system has

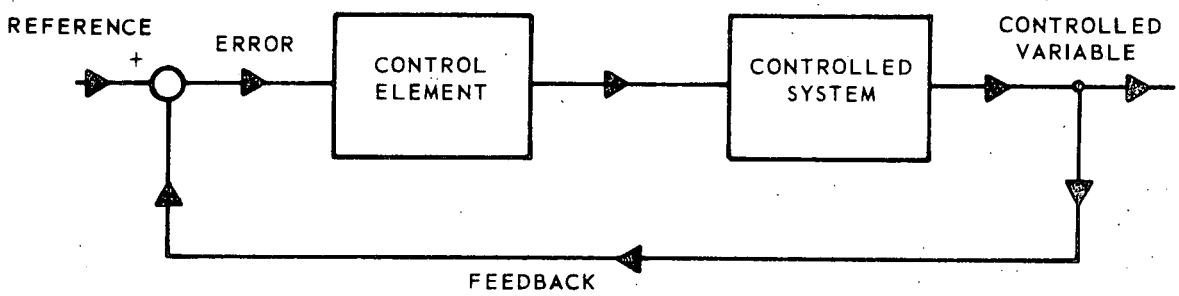
no means of sensing changes in the load of the generator, changes in generator speed, or in shunt field resistance thus is prone to vary when these conditions exist. Because it has no method of sensing existing conditions (feedback), it is an open loop system. See Figure 1-1, Comparison Diagrams - Open-loop and Closed-loop Control Systems.

If the generator control system could sense existing conditions and act accordingly, it would be a closed-loop system. Such a system would be composed of several components. The basic ones are an error-sensing device, the control element, and the controlled system. The error-sensing device emits an error signal to the control elements; the control elements amplify the error signal to operate the controlled system to obtain the controlled variable - the output.

In a closed-loop system, a portion of the output is fed back to the error-sensing device in opposition to the standard signal to obtain an error signal. When the feedback signal equals the standard signal, the error signal will be zero and the control system will be at rest.



a. **OPEN LOOP CONTROL SYSTEM** (Typical for trolley and bridge)



b. **CLOSED LOOP CONTROL SYSTEM** (Typical for main and auxiliary hoists)

Figure 1-1 Comparison Diagrams – Closed Loop/Open Loop Control Systems

If a rotating regulator exciter (Amplidyne or Metadyne) is used to supply shunt field current to the generator, and the connections are properly made, a feedback control system may be obtained. One rotating regulator field may be used to measure the difference between the reference voltage and the output voltage. The difference, or error voltage excites the rotating regulator. Due to its great power amplification and flexibility the rotating regulator exciter in this case is the error sensing device and the control element. The generator voltage is the controlled variable.

The closed-loop generator voltage control system will have considerable variation, but it will be considerably less than that of the original open-loop system. If the generator no-load voltage is 250 volts and the regulating system requires 10 volts for excitation, the reference voltage must be equal to 260 volts. This 10 volts required for system excitation is called the error voltage because it is the difference betweeen the desired voltage and the reference voltage. If the ratio of output-to-error voltage (system gain) is 25, a 1-volt change in error voltage will take care of a 25-volt change in output voltage. With the regulating loop or circuit established, when load is applied to the generator, the terminal voltage will drop from 250 to 249 volts instead of down to 225 volts. The 1-volt system regulation is all that is required to produce the additional 25 volts of generator internal voltage to compensate for generator IR drop or regulation. This is a simplified analysis of the problem and assumes that the machines are unsaturated, however, this case illustrates how a regulating system can improve steady-state performance. A simple equation can be written to express the relation worked out above. It is:

$$\text{System Regulation} = \frac{\text{Open-Loop Regulation}}{1 + \text{System Gain}}$$

For the example given:

$$\text{System Regulation } \frac{25 \text{ volts}}{1 + 25} = 0.96 \text{ volts}$$

The closed-loop control system will also have improved transient performance. When the reference voltage is changed, an error voltage many times normal is suddenly made available to force the change to the new operating level. As the desired voltage is approached, forcing decreases and the error approaches the steady-state value required to supply the system excitation.

A second feedback element is a load signal from the 100-millivolt shunt in the motor generator loop. Current in the loop is proportional to load. The "load-set" potentiometer provides a small command signal which is balanced by the feedback from the load via the shunt. This load set command and load feedback are essential to the operation of the "load float" which requires that the motor torque balance the load and friction torque.

Figure 1-2 Deleted

Smooth float or very low speed operation is impractical with tachometer feedback only since motion is required to give a feedback signal. This comes about largely because of the relatively low mechanical efficiencies of a hoist which are in the order of 70 to 80 percent. To illustrate: Assume a requirement of 100 HP to hoist a load with a hoist of 70 percent efficiency. Only 70 HP actually works on the load; the balance is lost in friction. This friction works with the motor when lowering the load. Seventy HP of work is done by the load, but only 70 percent, or 49 HP, is transmitted to the motor with the balance being used up by the mechanical losses. As a practical result, the current required to raise the load (since current is essentially equal to torque and torque times speed equal work or horsepower) is about double that required to hold back the load when lowering. This means that at heavy loads a wide range of current, as indicated on the console ammeters, will hold the load stationary with the brake released. Good operational practice requires that this current be kept as low as possible when floating the load.

1.2.8 Cab Control Console. (Refer to KSC drawing 67-K-L-11348 and Sections II and III of the Operating Manual.) The Operating Manual describes the instruments and controls in the control console. The operator and the instrumentation at the console must be the principal guide to the operating condition of the crane. It should be part of the training and routine maintenance procedures for those using this manual and responsible for taking care of the electrical equipment to be fully familiar with operation of the crane. Any difficulties in the equipment will be immediately apparent because of the precision inherent in a properly operating system. Smoothness of response, how the various motions start and stop, and current readings on the ammeters; are all characteristic of the system and how well it is performing.

The master switches perform multiple functions. Each, in conjunction with the related travel or hoist speed selector switch, covers either two or three speed ranges: fine, coarse, and high speed. All ranges will cover all the speeds through zero of the range selected. Obviously, around zero speed, the fine control range provides greater resolution because the approximate 110 degrees of master switch handle travel covers only 10 percent of the speed range.

The basic speed command is approximately ± 40 volts dc from a precision wire wound potentiometer driven by the master switch handle. There is a grounded center tap on each of the potentiometers. In the fine speed range, the selector switch adds additional resistance in the ± 40 volt regulated supply feeding the potentiometers so that the maximum voltage is approximately ± 3 volts.

Rated operating motor currents from test, as indicated on the individual drive ammeters, are posted in the cab. Directional contacts on the master switch operate directional relays located in the drive control panels, whose primary purpose is to set the brakes when the directional limit switches are tripped or when the master switch passes through the OFF position in changing direction or is placed in the OFF position.

The operator's console is provided with switches and pushbuttons to control crane motions; instrument dials; and warning and routine operation indicators to facilitate crane operation control. Crane controls and their arrangement on the console are shown on KSC drawing 67-K-L-11348 (Sheet 10).

The cab has one light controlled by a switch on the inner back wall of the cab. All other crane lights are controlled from the 3-way switches at the cab-end of each lower bridge walkway.

The cab control console has an upper and a lower panel, designated as panel "A" and "B". Table 1-1 lists the function and location of the controls and indicators mounted on these panels. For the wiring diagram of the control console, refer to KSC drawing 67-K-L-11348.

1.2.9 (Deleted)

1.2.10 Electrical Protective System. The electrical system of the 175-ton crane consists of various types of devices (temperature or current sensing) to protect the motors and motor-generator sets against overloading; motor field loss; under voltage; single phase (phase dropout when multiple phase is a requisite); phase reversal; over-temperature; instantaneous overloading; and overspeed.

Crane motions and motors are protected with limit switches which control hoist upper and lower limits; bridge travel limit (both ends); trolley travel limit (both ends); and limit travel speeds (forces deceleration) of the bridge to 7.5 feet per minute within 10 feet of end of travel at both ends and while crossing the joint between the low-bay and high-bay buildings.

TABLE 1-1

FUNCTION AND LOCATION OF CONTROLS AND INDICATORS MOUNTED IN CAB CONTROL CONSOLE

INDICATOR	CONTROL	FUNCTION	LOCATION
Shaft position readout		Indicates movement of each motion - Hoists - Bridge - Trolley.	Panel A
Digital Counters		Indicates movement of each motion in feet.	Panel A
RED Warning Light (13)		a. Hook swivel Pump ON. b. Drive motor overheating: Main Hoist (2) Bridge (4) Aux. Hoist (2) Trolley (2) c. HIGH SPEED engaged on MH & AH.	Panel A Panel B
AMBER Warning Light (15)		a. Hook swivel clutch ENGAGED b. Blower motor overheating Main Hoist (2) Bridge (4) Aux. Hoist (2) Trolley (2) c. COARSE speed engaged	Panel A Panel B
GREEN Indicator Light		a. FINE speed engaged b. Indicates Hook Swivel clutch UNLOCKED.	Panel B Panel A
WHITE Indicator Light		Main circuit breaker closed-power ON.	Panel A
	Switch, REMOTE CONTROL CABLE WINDER	Controls cable winder motor.	Panel A
	Switch, HOOK SPEED & DIRECTION CONTROL	Controls main hook swiveling	Panel A
	Switch, POWER SWIVEL	Locks and unlocks hook swivel clutch.	Panel A
	Pushbutton START/STOP (4)	M-G set START/STOP: Main Hoist (1) Bridge (1) Aux. Hoist (1) Trolley (1)	Panel A

TABLE 1-1 (Continued)

INDICATOR	CONTROL	FUNCTION	LOCATION
Ammeter (4)		Load current indicator: Main Hoist (1) Bridge (1) Aux. Hoist (1) Trolley (1)	Panel A
	EMERGENCY STOP Pushbutton	Emergency stopping of all crane motions. Shuts off all motors and sets brakes.	Panel A
Warning Horn		Motor overheating and used manually to warn personnel below.	
	Master Switch (4)	Manual control of crane motions: Main Hoist Bridge Aux. Hoist Trolley	Panel B
	Load Set (Float) Potentiometer (2)	Adjust motor control current to float a load. Main Hoist (1) Aux Hoist (1)	Panel B
	Speed Selector Switch (4)	Speed range selector: Main Hoist (1) Bridge (1) Aux. Hoist (1) Trolley (1)	Panel B
	Thumb latch on Master Switches	Locks switches in neutral position.	on Master switch
	Lever on side of Master Switch	Releases brakes for float operation with Master Switch in neutral position.	on side of Master Switch

Pages 1-11 through 1-20 Deleted
Tables 1-2 and 1-3 Deleted
Section II, Test Equipment and Special Tools, Deleted

SECTION III

PREVENTIVE MAINTENANCE

3.1 GENERAL

3.1.1 Preventive maintenance consists of regularly scheduled inspections of working components and necessary remedial action. A faithfully executed preventive maintenance program will insure the continuing satisfactory performance of the crane.

3.2 PREVENTIVE MAINTENANCE INTERVALS

3.2.1 The frequency of inspection recommended for the VAB 175-Ton Bridge Crane is based on average conditions of operation, temperature, humidity, and airborne dust. If any of these conditions are above normal, the interval should be shortened accordingly. If below normal, lengthen the interval. The actual frequency should be adjusted for each application as experience dictates.

3.3 PREVENTIVE MAINTENANCE PROCEDURE

3.3.1 Crane Exercising. Unless properly prepared for storage, lack of regular use of electrical components, especially motors, relays, and contactors, will be the principle cause of abnormal failures. During periods of inactivity or semi-storage the crane should be exercised for at least one hour at 7 to 10 day intervals and just prior to performing preventive maintenance inspections.

All motions and controls should be operated several times during the exercise period. This limited activity will allow the motors to warm up and drive out accumulated moisture, blow out loose dust before it becomes caked, and will operate the relays and contactors sufficiently to deter corrosion, oxide, or sulphide buildup.

During the exercise period, observe all visual indicators and meters for indication of proper functioning of all components. Refer to the operating Placard in the cab for approximate current values for full load conditions. If the ammeters indicate an abnormal condition, or crane functions are not normal, shut down the crane and refer to the Troubleshooting Chart in Section IV of this volume for probable cause and remedy.

3.3.2 Preventive Maintenance Chart. The preventive maintenance charts have been arranged according to the type of equipment and similarity of inspection. Each chart lists the recommended inspection interval, what to inspect for, and corrective action required.

NOTE

Read the complete set of NOTES at the end of the charts before beginning the inspection. Items which are sealed or require disassembly for inspection of the items listed are not to be included in the inspection.

WARNING

Disconnect power before attempting inspection. With power ON, lethal voltages are present within or adjacent to many of the control devices. No preventive maintenance should be performed with power ON.

CHART A

Equipment: Circuit Breakers; Contactors; Relays; Timers; Thermistor Controllers; Starters; Solenoids.

MONTHLY	SEMI ANNUAL	WHAT TO INSPECT FOR	CORRECTIVE ACTION
X	X	Loose connections.	Tighten.
X	X	Collections of dirt, gum or grease (Note 1)	Clean. (Refer to par. 5.2)
X	X	Excess heating (Note 2)	Check control-circuit voltage for correct value. Clean contacts to remove dirt, gum, grease, or oxide buildup.
X	X	Corrosion (Note 3)	Remove. (Refer to par 5.2)
X	X	Condition of Contacts (Note 4)	Clean and touch up as required (Refer to par. 5.2). If worn or excessively pitted, refer to manufacturer's data for action to take.
X	X	Condition of arc chutes or barriers (Note 5)	If worn or burned excessively, refer to manufacturer's data.
X	X	Excessive arcing (Note 6)	Refer to manufacturer's data.

CHART A (Continued)

MONTHLY	SEMI ANNUAL	WHAT TO INSPECT FOR	CORRECTIVE ACTION
X	X	Proper contact pressure (Note 7)	Refer to manufacturer's data.
X	X	Condition of flexible shunts (Note 8)	Refer to manufacturer's data.
X	X	Freedom of moving parts (Note 9)	Remove foreign matter or correct cause of binding and sticking. Apply lubricant per manufacturer's recommendation and crane lubrication chart in Volume I.
X	X	Wear (Note 10)	Refer to manufacturer's data.
X	X	Moisture (Note 11)	Dry with compressed air. Check for corrosion (Note 3) and correct if present (refer to par. 5.2).

CHART B

Equipment: Limit Switches; Control Switches; Selector Switches; Rheostats; Push Buttons; Motor Overspeed Control.

X	X	Loose connections	Tighten.
	X	Collection of dirt, gum or grease (Note 1)	Clean. (Refer to par. 5.2).
	X	Excess heating (Note 2)	Check control-circuit voltage for correct value. Clean contacts to remove dirt, gum, grease, or oxide buildup.
	X	Corrosion (Note 3)	Remove. (Refer to par. 5.2).
	X	Condition of Contacts (Note 4)	Clean and touch up as required. (Refer to par. 5.2). If worn or excessively pitted, refer to manufacturer's data for action to take.
	X	Freedom of moving parts (Note 9)	Remove foreign matter for correct cause of binding and sticking. Apply lubricant per manufacturer's recommendation and crane lubrication chart in Volume I.

CHART B (Continued)

MONTHLY	SEMI ANNUAL	WHAT TO INSPECT FOR	CORRECTIVE ACTION
	X	Wear (Note 10)	Refer to manufacturer's data.
	X	Moisture (Note 11)	Dry with compressed air. Check for corrosion (Note 3) and correct if present (refer to par. 5.2).
	X	Wear or roughness on sliding contacts. (Note 12)	Refer to manufacturer's data for recommendations.

CHART C

Equipment: Motors; Tachometer Transmitters; Selsyn Transmitters; Selsyn Receivers.

X	X	Loose connections.	Tighten.
X	X	Collection of dirt, gum or grease (Note 1)	Clean. (Refer to par. 5.2).
X	X	Excess heating (Note 2)	Check control-circuit voltage for correct value. Clean contacts to remove dirt, gum, grease, or oxide buildup.
X	X	Corrosion (Note 3)	Remove. (Refer to par. 5.2).
X	X	Freedom of moving parts (Note 9)	Remove foreign matter or correct cause of binding and sticking. Apply lubricant per manufacturer's recommendation and crane lubrication chart in Volume I.
X	X	Wear (Note 10)	Refer to manufacturer's data.
X	X	Moisture (Note 11)	Dry with compressed air. Check for corrosion (Note 3) and correct if present (refer to par. 5.2).
	X	Brushes for wear, corrosion, and oxidation	Refer to manufacturer's data for recommendations.

CHART C (Continued)

MONTHLY	SEMI ANNUAL	WHAT TO INSPECT FOR	CORRECTIVE ACTION
	X	Brush pressure	Refer to manufacturer's data for recommendations.
CHART D Equipment: Transformers; Resistors; Capacitors; Diodes; Transistors; Wiring; Buss.			
X	X	Loose connections	Tighten.
X	X	Collections of dirt, gum or grease (Note 1)	Clean. (Refer to par. 5.2).
X	X	Excess heating (Note 2)	Check control-circuit voltage for correct value. Clean contacts to remove dirt, gum, grease, or oxide buildup.
X	X	Corrosion (Note 3)	Remove. (Refer to par. 5.2).

3.3.3 Inspection Notes.

NOTE 1: Collections of dirt, gum, or grease. Visually check for these items, particularly in close proximity to current-carrying components and in areas which might restrict movement of moving parts. Loose connections, dirt, gum, and grease are the greatest cause of malfunction in electrical equipment.

NOTE 2: Excess heating. This is evidenced by discoloration of metal parts, charred insulation, or odor. Usually caused by overloading or by poor electrical contact due to foreign matter separating contact surfaces.

NOTE 3: Corrosion. Corrosion of metal parts due to atmospheric conditions is a common occurrence in electrical circuits. Visually check all components for signs of corrosion, oxidation, or sulphide buildup. This type of foreign material on contacting surfaces is a common cause of overheating, arcing, and failure of contacts.

NOTE 4: Condition of Contacts. Contacts should be clean, free of corrosion, oxidation, sulphide, dirt, gum, grease, or other foreign material which might prevent full electrical contact. Contact surfaces should not be excessively pitted or burned and be free of metallic spikes caused by arcing.

NOTE 5: Condition of Arc chutes and barriers. Visually check to make sure wear and arcing has not deteriorated arc chutes and barriers to point where possible malfunction might occur.

NOTE 6: Excessive arcing. Check for pitting, burning, and melted metal which are indicative of excessive arcing. Usually caused by foreign matter on contacts, insufficient contact pressure, excessive load on the line, or excessive voltage.

NOTE 7: Proper contact pressure. Excessive overheating usually leads to a weakening of the contact springs. Check to assure that contacts are held firmly in place in closed position.

NOTE 8: Condition of flexible shunts. These shunts are made of spring material and tend to lose their reflex qualities. Flex or twist the shunt to see if the material is "live."

NOTE 9: Freedom of moving parts. Proper action of some devices depends upon full freedom of moving parts. Check to see that these parts do not bind or stick.

NOTE 10: Wear. Look for pitting and abrasion of contacts, erosion due to sliding of moving parts, and excessive play in rotating shafts. Excessive play may result in misalignment and abnormal wear. Experience will dictate the amount of wear which can be tolerated. Refer to the manufacturer's data on the particular item for recommendations.

NOTE 11: Moisture. Moisture is a common enemy of electrical devices. Visually check for moisture, usually in the form of condensation, corrosion, or oxidation.

NOTE 12: Wear or roughness on sliding contacts. Devices with sliding contacts, straight or rotary, rely upon good contact for proper operation. Inspect for roughness or wear which might cause loss of contact and result in erratic operation.

SECTION IV

TROUBLESHOOTING

4.1 GENERAL

4.1.1 Troubleshooting on the 175-Ton Crane entails isolation of malfunctions through systematic testing of components as indicated by physical and visible malfunction signs. Point-to-point testing and relay interface action can be checked by referring to KSC drawing 67-K-L-11348:

a.	Sheets 12 through 20	Main and Auxiliary Hoists, Schematic Diagrams
b.	Sheets 25 through 28	Trolley, Schematic Diagrams
c.	Sheets 21 through 24	Bridge, Schematic Diagrams
d.	Sheet 29	Phase Failure and Lighting
e.	Sheet 30	Power Supply and Amplifier
f.	Sheet 31	Overspeed Protection, Main and Auxiliary Hoists

4.2 TROUBLESHOOTING CHART

4.2.1 A troubleshooting chart is provided to assist maintenance personnel in the isolation of defective components in the electrical system of the crane. The chart lists the visible symptom, and most probable item(s) to check. The usual procedure of troubleshooting starting at the unit which is malfunctioning and working back to the power source, should be followed. In the event that a circuit breaker trips, reset it. If it fails to hold, use the troubleshooting chart and reference drawings to ascertain the probable cause and remedial action to take.

Since the main and auxiliary hoist control system is a closed-loop (or servo) system, problems in some parts of the system may be reflected around the entire loop. To detect a faulty control relay, use jumpers to direct power to the control terminals to activate the relay and then check the various contact for closure or opening as the case may be. KSC drawing 67-K-L-11348 shows the relay contacts in normal condition (not activated).

NOTE

Maintenance personnel should be fully familiar with the operation of the crane and its normal indications. Refer to Volume I, Operating Instructions for correct operating procedures and other information concerning proper operation.

WARNING

The crane electrical system contains hazardous voltages. Personnel safety precautions must be followed at all times to avoid serious injury.

NOTE

Get a full report from the operator.

If equipment is shut down, look first to the operation of safety and protective equipment.

Visually inspect before performing any electrical checks.

Log all problems and solutions in record book.

TROUBLESHOOTING CHART

TROUBLE	ITEMS TO CHECK
Motor-Generator set does	1. Main Circuit breaker in MCC closed. (Power failure, or single phase, or reverse phase will open phase-reversal relay PRR and trip this breaker; the similar breakers for the other three motions would also be tripped.) 2. SR relay in drive control panel picked up. (Green light above motor-generator START button should be on. If green light comes on when START button is pushed but does not stay on, the overloads on the motor-generator set or Metadyne in the MCC or the OT device operated by the sensors in the motors have operated. 3. ICCB for closure and 480 volts at load terminals 11 and 12. 4. ICCB for closure and 120 volts at 13 and 14. 5. Field-loss relay not picked up.
Selsyn indicators unstable or running away	1. Dampening mechanism defective. (Replace indicator). 2. Loss of excitation.
No speed regulation	1. Defective dc power supply. 2. Open circuit in control loop. 3. Defective current limit amplifier. 4. Defective magnetic amplifier or Metadyne. 5. System voltage.

Page 4-4 Deleted
Figure 4-1 Deleted

SECTION V

MAINTENANCE

5.1 GENERAL

5.1.1 Maintenance on the 175-ton crane will consist primarily of periodic preventive maintenance (Section III) and correction of potential problems and such adjustment an repairs as indicated by troubleshooting of malfunctions (Section IV).

5.1.2 All electrical components of the crane controls are commercial parts. Maintenance of these items are covered by documentaion provided by the specific vendor and are included in the Appendix at the end of the Volume.

5.2 CLEANING

5.2.1 Dirt and Grease. Accumulations of dust and grease on control equipment (contactors, relays, solenoids, timers, rheostats, etc.) are the most common cause of malfunctions. Dry dust and dirt should be blown off, using dry compressed air. This is important as dust may not only prevent the control devices from operating normally, but may contain conducting material which will ultimately result in a short circuit. Grease, oil, or sticky dirt may be removed by use of a methyl chloroform cleaning fluid. Do not soak the parts with fluid-use just enough to loosen the deposit so that it can be wiped off. For small parts, a small paint brush, dipped into the cleaning solution, is a good instrument for getting into corners, crevices, and narrow openings.

5.2.2 Oxidation. Silver contacts occasionally are plagued by silver oxide when the equipment is not in extended use. This oxide may be reduced by cleaning in a manner similar to that used for removal of dust and grease (methyl chloroform application) and will be further reduced by application of the controls.

CAUTION

Silver contacts should not be filed to remove oxide formations. Filing will rapidly destroy the usefulness of the contacts.

5.2.3 Pitting. Contacts which are pitted from unusual arcing (usually from poor contact due to oxide buildup, weak spring, or improperly functioning holding coil), or have an "arc tip" projection buildup, should be filed lightly to smooth the contact

surfaces. Normal arcing will cause minor pitting of the contact surfaces and is a normal condition. A contact with minor roughness caused by normal service will carry the load as well as a smooth contact. The slight abrasion caused by normal closing will normally keep oxide cleaned off reasonably well thus preventing excessive arcing which causes extensive buildup on one or the other of the contacts.

As a contact wears, pressure is maintained by a wiping spring which presses the movable contact against the stationary contact when the contact is closed. Check this spring during preventive maintenance inspections and compare with correct spring pressure as indicated in manufacturer's data and recommendations.

5.3 through 5.6.2 (Deleted)

5.7 CONTROL SYSTEM POWER

5.7.1 General. Power for the 175-ton crane controls is taken from the VAB main line which is 480-volt, 60-cycle, 3-phase. Transformers and power supplies reduce this level to that required for control use.

5.7.2 Transformers. The nonregulating transformers provide an unregulated output which will fluctuate in proportion to the amount of fluctuation in the main line (480 volts). When troubleshooting the control system, make sure that the tolerances of the line are known. These are indicated on the various electrical schematics. If the main line voltage is within tolerance and the output of the transformer is not within its normal working range, a malfunctioning transformer is indicated. No adjustments are possible, therefore, the only corrective action available is removal and replacement of the faulty transformer.

5.7.3 Power Supplies. Each of the drive control systems uses +40 volts and -40 volts in its function. These voltages are provided by power supplies located in the drive control panel.

Two plug-in type solid-state power supplies, manufactured by Transistor Devices, provide unregulated +40 and -40 volts dc. These units are provided with a slotted head potentiometer shaft which may be adjusted with a screwdriver. A small amount of adjustment is available and if the voltage cannot be brought within tolerance (+38 to +42 volts or -38 to -42 volts) the power supply must be replaced. A schematic diagram of the power supplies is provided in the vendor information appendix of this volume.

5.8 SINGLE-MOTOR OPERATION

5.8.1 General. If any motion of the crane must be operated on only one of the pair of motors provided (except bridge travel which is accomplished by two pairs of motors), maintenance personnel must disconnect the inoperative motor (or pair of motors as used on the bridge) from the power source and rewire the control circuits before safe and satisfactory single-motor operation can be performed. Single motor operations will not be conducted (except for test) unless initiated by motor failure or malfunction. The equipment will operate satisfactorily on one motor as the principle and design are such that the regulating circuit will automatically limit the generator voltage to one-half of the normal output required for two-motor operation.

5.8.2 Single-motor Setup. To avoid excessive loading of the circuitry and provide maximum power to the remaining motor, the following procedure must be followed:

a. Disconnect armature leads of failed motor at motor junction box. Attach jumper across the armature lead terminals to close the circuit. If the circuit is allowed to remain open, the second motor will not operate as the armatures of both are connected in series.

b. Disconnect the field leads of the failed motor at the motor junction box. Tape ends of loose leads to prevent shorting. Shorted leads will divert excessive current from the second motor of the needed power and setting up a situation conducive to failure of the second motor.

CAUTION

1. Instruct crane operator to limit his control to less than one-half of the total control travel available.

2. Instruct crane operator not to attempt hoist operation with the speed control set for HIGH SPEED.

3. If the failed motor is one of the bridge motors (there is one at each corner of the bridge), disconnect the corresponding motor at the other end of the bridge. This will equalize the remaining power and prevent the bridge from "crabbing" during travel.

NOTE

Single motor operation is performed at decreased voltage (1/2 of normal) and increased current (twice normal) on the remaining motor. The control circuits automatically set up this condition upon failure of a motor. Indicating instruments in the control console will detect this and indicate twice the normal values. Advise operator of this condition so that he is aware of cause of high readings which are normal under single-motor operating conditions.

Pages 5-5 through 5-13 Deleted
Section VI, Parts List, Deleted
Appendix A, Reference Drawings, Deleted