IMPULSE TEST REPORT

Manufacturer R.E. Uptegraff Mfg. Co. Spec. 10340 Order Number G-2832
Purchased by Crawford Electric Supply Company Order Number S001852043
Cooling Class XNAN Phase 3 Hertz 60 Insulating Fluid FR3
Serial No. 5A13 Test No. 10340

H.V.	69000 DELTA	L.V.	2400	T.V.	
H.V. KV B.I.L.	350	L.V. KV B.I.L.		T.V. KV B.I.L.	
H.V. CW KV CREST		L.V. CW KV CREST		T.V. CW KV CREST	
H.V. MIN. CHOP TIME μS		L.V. MIN.CHOP TIME μS		T.V. MIN.CHOP TIME μS	
H.V. RFW CREST TIME μS	1.3	L.V. RFW CREST TIME μS		T.V. RFW CREST TIME μS	

TERM TESTED	WAVE TYPE	CREST KV	½ CREST TIME(μs)	TIME TO CHOP(μs)
H1	RFW	198.2	46.2	-
H1	FW1	385.4	38.0	-
H1	FW2	340.9	35.0	-
H2	RFW	192.7	44.7	-
H2	FW1	388.3	34.0	-
H2	FW2	351.0	38.0	-
H3	RFW	230.2	36.0	-
H3	FW1	380.9	41.0	-
H3	FW2	356.0	36.0	-

Each voltage wave will have an accompanying current wave.

RFW = REDUCED FULL WAVE
RGC = REDUCED GROUND CURRENT
CW = CHOP WAVE
FW = FULL WAVE
GC = GROUND CURRENT

I HEREBY CERTIFY THAT THIS IS A TRUE REPORT BASED ON FACTORY TESTS PERFORMED IN ACCORDANCE WITH AMERICAN STANDARD TEST CODE FOR DISTRIBUTION, POWER & REGULATING TRANSFORMERS C57.12.

Date 8/23/2013

R. E. UPTEGRAFF MFG. COMPANY
P.O. Box 182
Scottdale, PA 15683

Customer:	Crawford Electric		KVA (base):	2500
Cust. P.O.:	S001852043	Voltage:	HV:	69000
			LV:	2400
Order No.:	G-2632R1		Spec. :	10340
S/N:	5A13			

R.I.V. TEST REPORT

TIME			% RATED VOLTAGE	H1 µv (rise)	H2 µv (rise)	H3 µv (rise)
	AMB.	µv	0	0.5	0.6	0.5
0 (min.)			150	150	250	170
5 (min.)			150	50	250	120
10 (min.)			150	60	120	120
15 (min.)			150	60	100	100
20 (min.)			150	35	100	80
25 (min.)			150	35	80	70
30 (min.)			150	35	70	70
35 (min.)			150	30	75	70
40 (min.)			150	35	80	70
45 (min.)			150	35	85	70
50 (min.)			150	40	90	70
55 (min.)			150	40	90	70
60 (min.)			150	35	90	60
65 (min.)			150	35	90	60

9/19/2013 Approved by:

Cargill

CERTIFICATE OF ANALYSIS

FR3 ENVIROTEMP FR3 FLUID ™
REVOLUTIONARY RELIABLE RESPONSIBLE

From
CHICAGO WAREHOUSE
12201 SOUTH TORRENCE AVE
CHICAGO, IL 60617
IOLCustomerService@Cargill.com

ShipTo
R E UPTEGRAFF MANUFACTURING CO
120 UPTEGRAFF DR
SCOTTDALE, PA 15683

Product Description: ENVIROTEMP FR3 FLUID TOTE 330 GALLON

Lot Number 13E20 Load Number: 43661 Customer PO No: 8378

Test Description	Results	ASTM D6871
Dissipation Factor, 100 °C [%]	2.3	≤ 4.0
Dissipation Factor, 25 °C [%]	0.06	≤ 0.20
Water Content [mg/kg (ppm)]	32	≤ 200
Acid Number [mg KOH/g]	0.05	≤ 0.06
Viscosity, 100 °C [mm²/s]	8	≤ 15
Viscosity, 40 °C [m.n²/s]	32	≤ 50
Appearance	Bright and Clear	Bright and Clear
PCB Content [mg/kg (ppm)]	Not Detectable	Not Detectable
Color [ASTM units]	L0.5	≤ 1.0
Corrosive Sulfur	Not Corrosive	Not Corrosive
Dielectric Breakdown, 2 mm gap [kV]	66	≥ 35
Fire Point [°C]	360	≥ 300
Flash Point [°C]	348	≥ 275
Pour Point [°C]	-18	≤ -10

FM APPROVED

Signed By:

Page 1 of 1

Envirotemp™ FR3™ Fluid

AS TO FIRE HAZARD ONLY
Envirotemp® FR3. Classed 4 to 5 less hazardous than paraffin oil in respect to fire hazard.

AS TO SECTION 450-23 OF THE NATIONAL ELECTRICAL CODE®
Also Classified as a "less–flammable liquid" in compliance with the National Electric Code®, when used in 3 phase transformers, 45 through 10,000 kVA with the following three "use restrictions":

A For use only in 3–phase transformers having tanks capable of withstanding an internal pressure of 12 psig without rupture, and

B Required use of pressure relief devices on transformer tank in accordance, with the following tabulation to limit internal pressure buildup and prevent tank rupture due to gas generation under low current arcing faults, and

C1 Required use of current limiting fusing in the transformer primary having I^2t characteristics not exceeding the values in the following tabulation. Under–fluid expulsion fuses may be used in series with the current–limiting fuses, in accordance with the manufacturer's protection scheme

OR

C2. Required use of overcurrent protection in the transformer primary having I^2t characteristics not exceeding the values in the following tabulation. If the fuse is designed to vent during operation (such as an expulsion fuse), it shall be located external to the transformer tank.

TRANSFORMER	REQUIRED PROTECTION		REQUIRED PRC
3 - Phase Transformer Rating kVA	Required Current Limiting Fusing (+) Maximum I^2t (A^2s)	OR Required Overcurrent Protection (-) Maximum I^2t (A^2s)	Minimum Required Pressure Relief Capacity, (++) SCFM of 15 psi
45	500,000	700,000	35
75	500,000	800,000	35
112.5	550,000	900,000	35
150	600,000	1,000,000	50
225	650,000	1,200,000	100
300	750,000	1,400,000	100
500	900,000	1,900,000	350
750	1,100,000	2,200,000	350
1,000	1,250,000	3,400,000	350
1,500	1,500,000	4,500,000	700
2,000	1,750,000	6,000,000	700
2,500	2,000,000	7,500,000	5,000
3,000	2,250,000	9,000,000	5,000
3,750	2,500,000	11,000,000	5,000
5,000	3,000,000	14,000,000	5,000
7,500	3,000,000	14,000,000	5,000
10,000	3,000,000	14,000,000	5,000

(+) – This is an additional requirement to the overcurrent protection required in accordance with Section 450-23 of the current date of the National Electrical Code®

(++) – Opening pressure, 10 psig maximum

Cargill 35H9

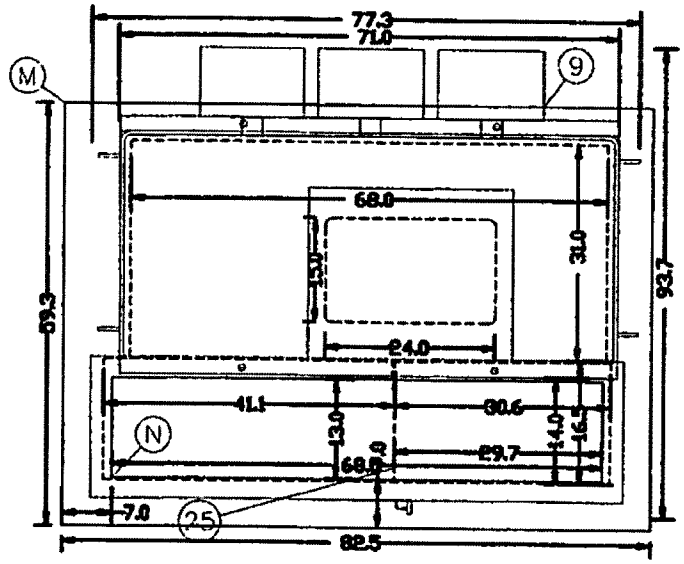
Cargill, Inc
Hopkins MN 55343 U S A.

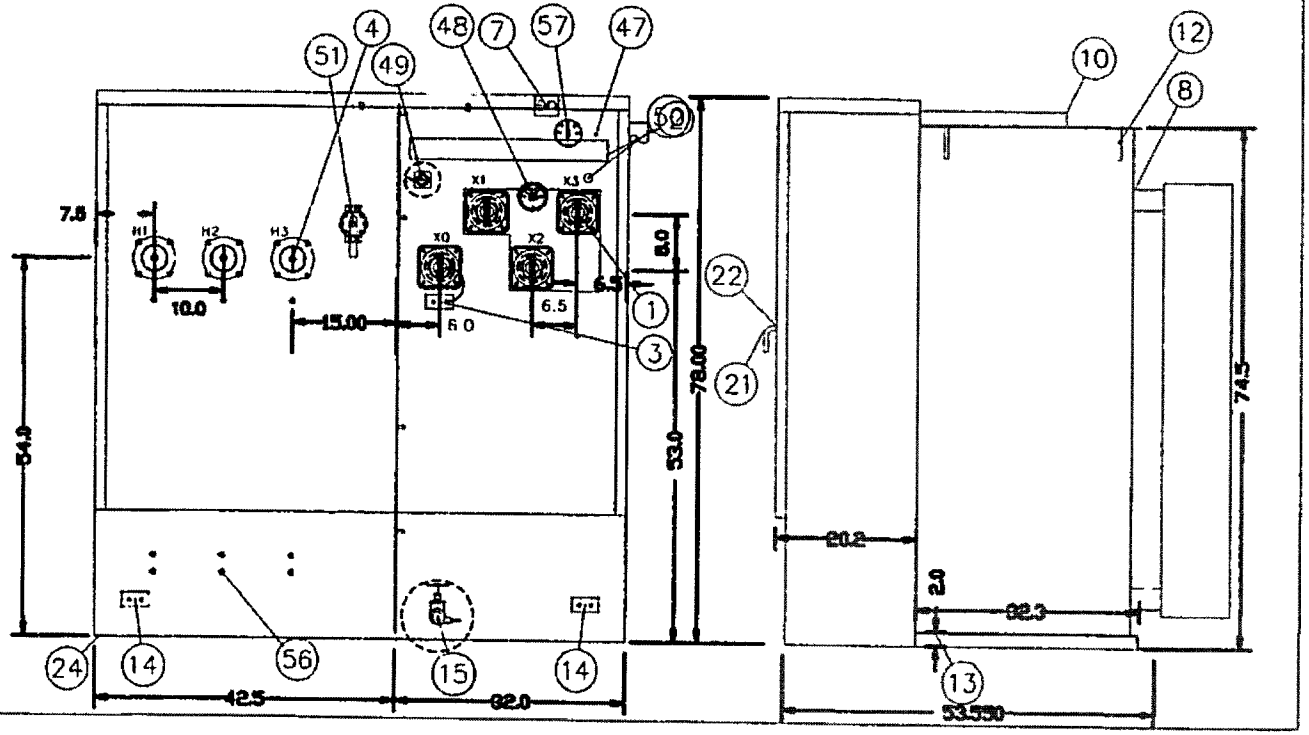
	DESCRIPTION
1	LV BUSHING W/INT. 10H SPADE
2	LV SPADE SUPPORT
3	2 HOLE HORIZ NEMA GRD PAD
4	HV PORC 75BIL W/2H G-SPADE
7	NP ON DOOR, SERIAL ON TANK
8	TANK
9	COOLING RADIATORS
10	HANDHOLE & SECURITY COVER
12	LIFTING LUGS
13	JACKING PROVISIONS
14	2 HOLE HORIZ NEMA GRD PAD
15	1 IN DRAIN VALVE AND SAMPLER
21	PADLOCKABLE DOOR HANDLE
22	3 PT LATCH PENTA SEC BOLT
24	18 IN REMOVABLE SILL
25	METAL LV-HV BARRIER
47	PRESSURE RELIEF VALVE
48	DIAL THERM W/MAX POINTER
49	2" MAGNETIC LL GAUGE
50	OIL LEVEL PLUG
51	TAP CHANGER HANDLE
56	PROVISIONS FOR LTG ARR
57	PRES VAC GAUGE

	SPECIAL NOTES
A	
B	
C	
D	
E	

CAT NO	9369435499059		
DWG BY	WM	DATE	11/10/09
APP BY	CB	CC	745

M	SUGGEST PAD SIZE	82.5 X	59.3
N	SUGGEST HOLE SIZE	68.5 X	13.0





DWG NO.	00731702343.378		
SUNBELT	SUNBELT TRANSFORMER TEMPLE, TEXAS		
CUSTOMER :			
SPEC. INQ NO-SPEC		DATED	
KVA 2550 OBIL 60 TAPS TS-2 ABOVE 2 BELOW			
HIGH VOLTAGE	2400		
LOW VOLTAGE	480Y/277		
APPROX. CORE AND COIL WEIGHT			5663
APPROX. TANK AND ACCESS. WEIGHT			3536
GAL. OF OIL	559	APPROX WEIGHT	4193
APPROX. TOTAL WEIGHT			13392

REV.	DATE	DESCRIPTION	BY / APP
A			

00731702343.378

0.043

9369230*S,NM,514, 0 H01 , 0, 5, %@

726831, 787469,1, 4262,2, 25887

59306808 *10

SUNBELT Transformer

SUNBELT TRANSFORMER LTD
Certified Test Report 09-29-11
Performance at 60 HZ and 85 C.

Customer Name:	**Sunbelt Transformer**	
Customer Number:	**438047 - - 438047**	**Order = 8364 Item: 002**
Customer P.O. Ref. No:	**NHI24100-2**	**Sunbelt Order #**
Bill of Lading Number:	**805925**	**Date = 09-29-11**
Catalog Number:	**9369-435499-059**	
KVA Size, Phase, & Type:	**2550.0 KVA 3 Phase Padmount**	
Voltage Desc. & Stock:	**2400 Delta 480Y/277**	
High Voltage:	**2400**	

Serial #	100% Voltage Core Loss	100% Load Cond. Loss	100% Total Loss	100% Voltage Ex. Cur.	%IR	%IX	%IZ	Date Tested	% Regulation @.80 PF	% Regulation @1.0 PF
1666761711	3830	25726	29556	0.70	1.01	6.11	6.19	05-24-11	4.56	1.19
Average	3830	25726	29556	0.70	1.01	6.11	6.19		4.56	1.19

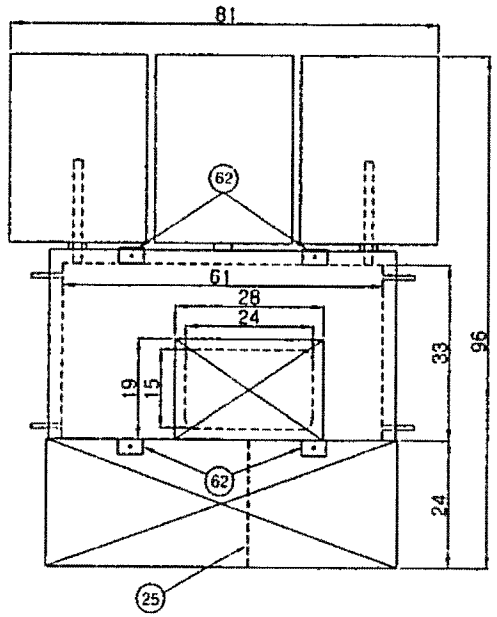
Total Quantity: 1

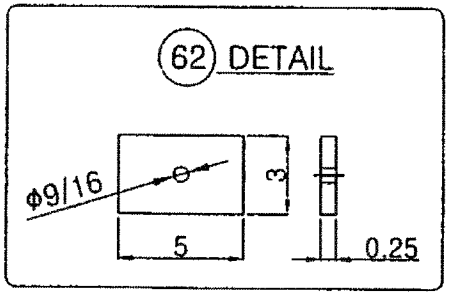
SUNBELT TRANSFORMER HEREBY CERTIFIES THAT THIS TEST REPORT IS A TRUE AND ACCURATE RECORD OF FINAL PRODUCTION LINE TESTS THAT WERE CONDUCTED IN ACCORDANCE WITH CURRENT ANSI TRANSFORMER TEST STANDARDS.

DWG NO.	0073475041.775		
SUNBELT TRANSFORMER			
CUSTOMER	SUNBELT		
SPEC.	DATED		
kVA	2550		
HIGH VOLTAGE	2400 DELTA (60kV BIL)		
LOW VOLTAGE	480Y/277 (30kV BIL)		
APPROX. CORE AND COIL WEIGHT			5776
APPROX. TANK AND ACCESS.WEIGHT			5481
GAL. OF OIL 430, APPROX WEIGHT			3051
APPROX. TOTAL WEIGHT			14308

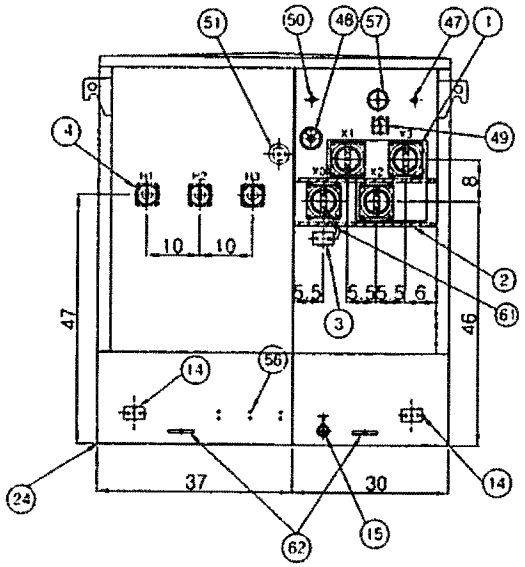
REV.	DATA	DESCRIPTION	BY / APP
A			
ID	31ST3215	P N 0073475041 775	

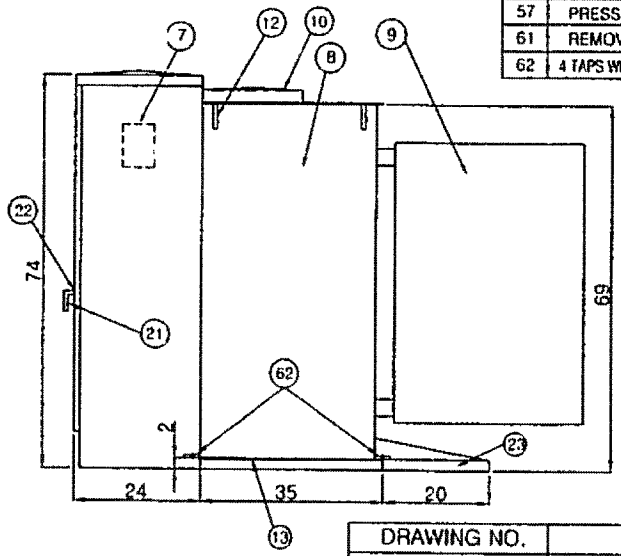
*COLOR Green Munsell#7.0GY-3.29/1.5





NO.	NAME
1	LV BUSHING & 10 HOLE (HJ-AS1168-016)
2	LV BUSHING SUPPORT
3	2 HOLE HORIZ NEMA GRD PAD
4	HV BUSHING & 4 HOLE (HJ-AS1276-008)
7	NAME PLATE ON DOOR & SERIAL NO ON NAME PLATE
8	TANK
9	COOLING RADIATORS
10	HAND HOLE & SECURITY COVER
12	LIFTING LUGS
13	JACKING PROVISIONS
14	2 HOLE HORIZ NEMA GRD PAD
15	1 IN DRAIN VALVE WITH SAMPLER
21	PAD LOCKABLE DOOR HANDLE
22	3 PT LATCH PENTA SEC BOLT
23	BASE SUPPORT
24	REMOVABLE SILL
25	METAL LV-HV BARRIER
47	PRESSURE RELIEF VALVE
48	DIAL TYPE THERMOMETER (HL-HTG3117)
49	LIQUID LEVEL GAUGE (TAUIN-T0206)
50	1 IN FILL PLUG
51	TAP CHANGER
56	PROVISONS FOR LTG ARR
57	PRESSURE VACUUM GAUGE (HL- HPG2000)
61	REMOVABLE GROUND STRAP
62	4 TAPS WITH A HOLE OF 9/16" FOR ANCHORING PROVISIONS





PO 24096
2550kVA

3	11.03.14		HJ PARK	SL CHOI	YK CHOI	YK CHOI
2	11.03.03		HJ PARK	SL CHOI	YK CHOI	YK CHOI
1	11.02.25	DESCRIPTION OF REVISION	DWG	DGN	CHECK	APP

THICKNESS		
a	SIDE	0.2 Inch
b	BOTTON	0.24 Inch
c	COVER	0.24 Inch
d	RADIATOR	0.05 Inch

DRAWING NO.	HCI-24096-02-001					
DATE	ITEM					
2011.02.25	TRANSFORMER 2550kVA					
APP	CHECK	DGN	DWG	SCALE		TOL.
YK.Choi	YK.Choi	SL.Choi	HJ.Park	N	S	±5
SUNBELT TRANSFORMER			TITLE	OUT LINE		

Sunbelt Transformer Detailed Test Report

Company	: Enchanted Rock Electric LLC	**Order No**	: A32589
Person	:	**Serial No**	: ST0713A32589-1-1
Address 1	: 1907 Lawrence Road, Suite 400	**Type**	: PAD/ONAN/ONAF
Address 2	:	**Date Tested**	: 07/30/2013
City, Sate, Zip:	Kemah, TX, 77565	**Manufacturer**	: HANG CHANG
E-mail:	**Fax #:**	**Stock No**	: NHC24096-2

P. O. No. : Kevin Presto **HZ:** 60 **Phases:** 3 **Temp Rise:** 65 :

High Voltage:	2400	:	:	**HV DW:**	Delta	**HV Conductor:**	Al
Low Voltage:	480	: Y	: 277	**LV DW:**	Wye	**LV Conductor:**	Al

KVA for testing/reporting: 2,550.0

KVAs:

55C/OA:		**55C/FA:**		**55C/FFA:**	
65C/OA:	2550	**65C/FA:**	2856	**65C/FFA:**	
80C/AA:		**80C/FA:**			
115C/AA:					
130C/AA:					
150C/AA:		**150C/FA:**			

MEGGER TESTS

: 2.5 KV	**High - Low:**	2320	**Megohms**
: 1 KV	**Low - Ground:**	2160	**Megohms**
: 2.5 KV	**High - Ground:**	3020	**Megohms**
: KV	**Core - Ground:**		**Megohms**

Conductor Temperature During Testing: 20.0

RATIO TESTS

Tap	Tap Volts	Calculated Ratio	Phase A : H3 : H1 To: X0 : X1	Phase B : H1 : H2 To: X0 : X2	Phase C : H2 : H3 To: X0 : X3
: 1	: 2520	: 9.097	: 9.0903	: 9.0898	: 9.0890
: 2	: 2460	: 8.881	: 8.8881	: 8.8888	: 8.8893
: 3	: 2400	: 8.664	: 8.6895	: 8.6891	: 8.6895
: 4	: 2323	: 8.386	: 8.3884	: 8.3892	: 8.3885
: 5	: 2268	: 8.188	: 8.1868	: 8.1874	: 8.1871
:	:	: 0.000	:	:	:
:	:	: 0.000	:	:	:

Remarks:

RESISTANCE MEASUREMENTS

High Voltage Winding Resistance, Values in ohms.

Tap	Phase A : H3 To: H1	Phase B : H1 To: H2	Phase C : H2 To: H3
: 1	: .01431	: .01430	: .01438
: 2	: .01402	: .01400	: .01411
: 3	: .01370	: .01368	: .01377

: 4	: .01326	: .01325	: .01333
: 5	: .01294	: .01298	: .01301
:	:	:	:
:	:	:	:

Low Voltage Winding Resistances, Values in ohms.

Phase A	Phase B	Phase C
: X0 To: X1	: X0 To: X2	: X0 To: X3
: 0.0003419	: 0.0003250	: 0.0003245

No-Load Loss Measurements (Average of three phase values)

RMS Volts: 2400 AVE Volts: 2400 Exciting Amps: 2.12 Watts Loss: 3520

Full-Load Loss Measurements (Average of three phase values)

LV Full Load (Line) Amps: 3,067.2 HV Full Load (Line) Amps: 613.4

Measured Amps: 613.3 Impedance Volts: 142.5 Watts Loss: 22740

Insulating Fluid: FR3 Tested by: JEM

D877 Dielectric Test on Insulating Fluid: 25

Calculated Results

Reference Temperature for Calculated Results	85 °C
Load Loss	26,079
No-Load Loss	3,371
Total Loss	29,451
Percent Exciting Current @ 100% Voltage	0.35
Percent Impedance	5.96
Percent Resistance	1.02
Percent Reactance	5.87
Percent Regulation @ 1.0 PF	1.20
Percent Regulation @ 0.8 PF	4.42
Percent Efficiency @1.0 PF & 1.0 PU Load	98.86
Total HV Winding Resistance	0.078
Total LV Winding Resistance	0.00125

Miscellaneous Constants

RHm: 0.062 RXm: 0.00099 HV Winding Amps: 354.2 LV Winding Amps: 3,067.2

Nominal HV Ohms : **0.014 : 0.014 : 0.014**

HV Winding Style: **D** LV Winding Style: **Y**

K(H) Al/Cu: **225.0** K(X) Al/Cu: **225.0** K(S) Al/Cu: **225.0**

MVA Interrupting Rating of Circuit Breakers Used in Metal-Clad Switchgear

September 22, 1993

Modern medium voltage circuit breakers used in metal-clad switchgear have no MVA interrupting rating. Undoubtedly, this statement will come as a surprise to some readers of this PTB. Although it is quite common for all of us to talk about 500 MVA circuit breakers or 1000 MVA circuit breakers, this rating does not appear anywhere in the ANSI standards applying to these breakers, nor does it appear anywhere on the nameplate of the breakers.

A little history is in order. The first ANSI standards covering circuit breakers, including those for use in metal-clad switchgear, were developed about 50 years ago. Under these standards, interrupting ratings were based on the total current interrupted, including the dc component. These "total current" standards included ANSI C37.4 through C37.9 and C37.12. In the rating structure used in these standards, MVA was included, and those of us who date back to that era got used to referring to breakers by their MVA rating.

In 1964, a new series of ANSI standards were first published. These standards used symmetrical, rather than total, current as the basis for interrupting rating. These new standards no longer referred to MVA in their rating structure. The interrupting rating in these standards is expressed kiloamperes. After a couple of decades of development, these standards now include six documents:

- ANSI/IEEE C37.04-1979 Rating Structure
- ANSI C37.06-1987 Preferred Ratings
- ANSI/IEEE C37.09-1979 Test Procedure
- ANSI/IEEE C37.010-1979 Application Guide - General
- ANSI/IEEE C37.011-1979 Application Guide - Transient Recovery Voltage
- ANSI/IEEE C37.012-1979 Application Guide - Capacitance Current Switching

However, so that manufacturers would not have to retest all their breakers, certain equivalences were established, and for a few years the preferred rating tables carried "nominal" MVA ratings for "identification". This last appeared in the 1971 edition of ANSI C37.06, but was missing from the 1979 edition. Unfortunately, we have continued to use these identifications informally, and sometimes we get wrapped around the axle about just what they mean, particularly when applied to circuit breakers used at a voltage considerably less than their rated maximum voltage, such as 4760 V breakers used at 2400 V. The chart below compares the nominal MVA ratings to the actual MVA ratings calculated using the rated interrupting currents established in the current standards.

Powell Industries, Inc.
PO Box 12818
Houston, TX • 77217

Tel: 713 944 6900 • Fax: 713.947.4453
www.powellind.com
info@powellind.com

MVA Interrupting Rating of Circuit Breakers Used in Metal-Clad Switchgear

page 2

Rated Maximum Voltage	Rated Short Circuit Current	Nominal	System Operating Voltage	Interrupting Current @ Operating Voltage	Actual MVA @ Operating Voltage[1]
kV, rms	kA, rms	MVA	kV, rms	kA	MVA
			4.76	29	239
4.76	29	250	4.16	33	238
			2.4	36	150
			4.76	41	338
4.76	41	350	4.16	47	338
			2.4	49	204
			8.25	33	472
8.25	33	500	7.2	38	472
			6.6	41	469
			15.0	18	468
15.0	18	500	13.8	20	478
			11.5	23	458
			15.0	28	727
15.0	28	750	13.8	30	717
			11.5	36	717
			15.0	37	961
15.0	37	1000	13.8	40	956
			11.5	48	956

(1) Slight variations in MVA may be due to rounding of interrupting current values

If you are interested in the development of these standards, a good history of these standards appears in the forewords of the various documents.

Baldwin Bridger, P.E.
Technical Director

Powell Industries, Inc
PO Box 12818
Houston, TX • 77217

Tel: 713.944 6900 • Fax: 713.947.4453
www.powellind.com
info@powellind.com

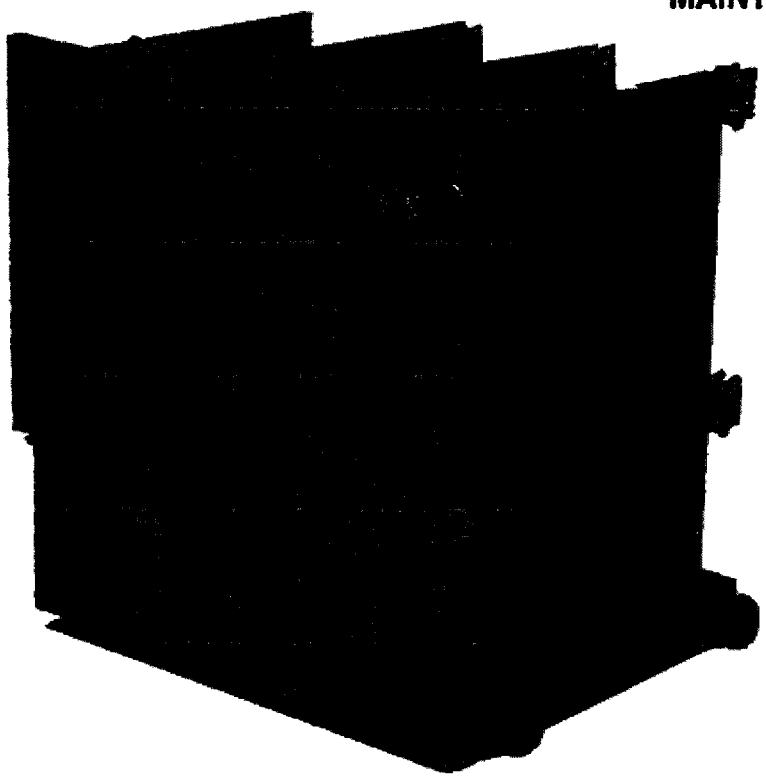
Series P-60000 POWL-VAC® VACUUM CIRCUIT BREAKERS

Models 05PV0250-3 and 15PV0500-3

INSTALLATION

OPERATION

MAINTENANCE



POWELL INDUSTRIES, INC.

POWELL ELECTRICAL MANUFACTURING COMPANY
8550 MOSLEY DRIVE • HOUSTON, TEXAS 77075 USA
PHONE (713) 944-6900 • FAX (713) 947-4453

CONTENTS

ILLUSTRATIONS

TABLES

CAUTION

Before any adjustment, servicing, parts replacement, or any other act is performed requiring physical contact with the electrical working components or wiring of this equipment, the POWER SUPPLY MUST BE DISCONNECTED.

I. INTRODUCTION

Before uncrating the breakers, study this manual. Follow the recommended procedure for putting into service.

This manual contains:

1. Safety Rules.
2. A general description of the operation of the circuit breakers.
3. Instructions for putting into service.
4. Instructions for maintenance and replacement of parts with critical adjustments.
5. List of renewal parts.

These instructions do not purport to cover all details or variations of the circuit breakers nor to provide for every possible contingency or hazard to be met in connection with installation, testing, operation and maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the user's purposes, the matter should be referred to the Powell Electrical Manufacturing Company.

II. SAFETY

The circuit breakers described in this manual are operated by high energy, high speed mechanisms interlocked to provide safe operating sequences. To insure the safety of personnel associated with installation, operation and maintenance of these breakers, the following rules should be observed:

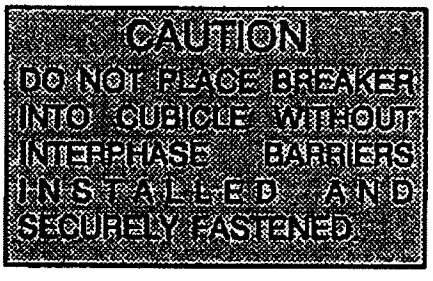
1. Only qualified personnel trained in the installation, operation and maintenance of power circuit breakers should be allowed to work on these breakers.
2. Do not work on an energized breaker.
3. Do not work on a breaker with the secondary test coupler connected (See Figure 17).
4. Do not work on a closed breaker.
5. Do not work on a breaker with closing springs charged.
6. Do not attempt to close the breaker by hand on a live circuit.
7. Do not use an open circuit breaker by itself as the sole means of isolating a high voltage circuit. For complete isolation, the circuit breaker should be in the disconnected position, or should be withdrawn completely.
8. For the safety of personnel performing maintenance operations on the breaker or connected equipment, all components should be disconnected by means of a visible break and securely grounded.

A. X-RAYS

When voltage is applied across the contacts of a vacuum interrupter, there is the possibility of generation of X-rays. The intensity of this radiation is dependent on the peak voltage and the contact gap. At the normal operating voltage of this class of equipment, the radiation levels are negligible. At the voltages specified for testing, it is recommended that the test operator be not less than one meter in front of the circuit breaker and separated from the vacuum interrupters under test by the two thicknesses of steel used in the construction of the circuit breaker frame. The circuit breaker must be either fully open or fully closed when making high potential tests. Do not test with contacts partially open.

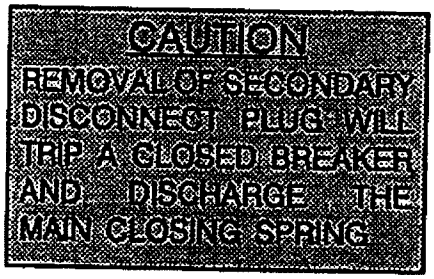
B. SAFETY LABELS

The circuit breaker has these warning and caution labels attached at the indicated locations. Whenever the circuit breaker is handled or maintained, these warnings and cautions must be observed.



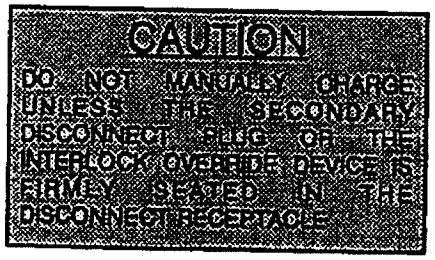
Attached to outside face of mechanism top cover plate.

Attached to outside face of mechanism top cover plate.



Attached to front cover to left of secondary disconnect aperture.

Attached to front cover at top right hand corner and also in mechanism compartment on dashpot bracket.



Attached to front cover to left of manual charging handle socket.

III. DESCRIPTION

A. GENERAL (Figure 1)

The Powl-Vac Circuit Breaker uses sealed vacuum interrupters to control the primary circuit. Primary connections to the associated metal clad switchgear are made by parallel copper busbars terminating in multiple contact fingers which are part of the busbars. Insulators provide support for the primary bars and the vacuum interrupter assemblies.

All the current carrying components are located behind a metal barrier which supports the insulators. In front of this barrier in an accessible position is the operating mechanism assembly which provides motion to each of the vacuum interrupter moving contacts through cast cycloaliphatic epoxy operating rods. In the same metal enclosed compartment as the operating mechanism is the levering-in mechanism which controls the movement of the breaker from the disconnected to the connected position. The levering-in mechanism engages with the switchgear and exerts a force on the breaker in a plane mid-way between the primary disconnect fingers, thus ensuring equal wipe on all primary disconnects and avoiding any tendency of the breaker to tilt under short circuit conditions. The levering-in mechanism also operates the primary disconnect shutters.

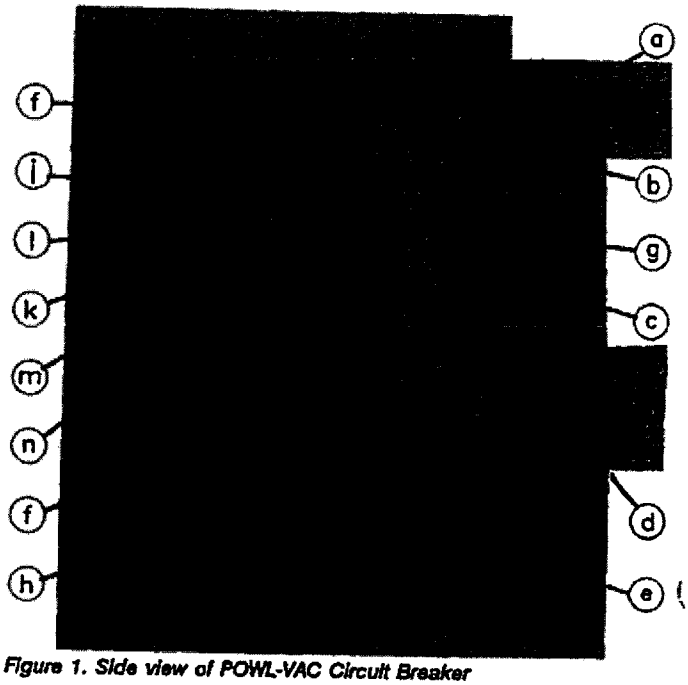


Figure 1. Side view of POWL-VAC Circuit Breaker

a. Upper Horizontal Primary Disconnect Bars
b. Vertical Connector Bars
c. Vacuum Interrupter
d. Lower Horizontal Primary Disconnect Bars
e. Ground Shoe
f. Main Insulating Supports
g. Insulating Pole Support
h. Main Insulating Operating Rod (Push Rod)
j. Mechanism Housing
k. Levering-In Crank Arm
l. Crank Arm Rollers
m. Levering-In Shaft
n. Worm Wheel

B. THE STORED ENERGY MECHANISM

The front cover (Figure 2) has cutouts and apertures giving access to various operating and levering-in mechanism indicating and operating functions and access to the secondary disconnect terminal block.

Removal of nine (9) holding screws enables the front cover to be removed giving access to the stored energy mechanism and its interlocks, auxiliary switches, levering-in operators and interlocks, operating motor and motor cutoff switch (Figure 3).

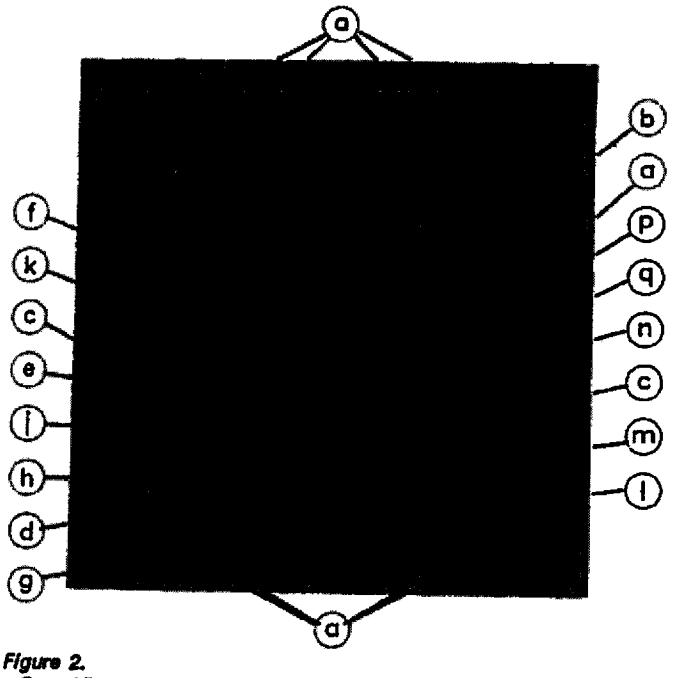


Figure 2.
Front View of POWL-VAC Circuit Breaker with Cover in Place

a. Cover Attachment Bolts
b. Breaker Position Indicator
c. Handle
d. Operations Counter
e. Manual Charging Crank
f. Nameplate
g. Spring Charge Indicator
h. Manual Close Paddle
j. Breaker Open/Closed Indicator
k. Manual Trip Paddle
l. Secondary Disconnect Guide
m. Secondary Disconnect Receptacle
n. Padlock Provision - Movable Arm
p. Padlock Provision - Stationary Clip
q. Levering-In Shaft Shutter

The mechanism is of the stored energy type in which a gear motor is used to compress a closing spring. During a closing operation, the energy stored in the closing spring is used to close the vacuum interrupter contacts, compress the overtravel springs, charge the opening springs and overcome friction forces. When the breaker is tripped, the energy stored in the opening and overtravel springs will open the contacts at the correct speed. The motor, located on the breaker floor pan bottom right, is supported by a bracket bolted to the floor pan (Figure 4). Its output shaft is screwed to a coupler which inserts into the eccentric drive shaft. This shaft is supported in needle bearings in the mechanism frame side sheets and transmits the motor torque from the right to the left side of the mechanism.

When the motor is energized, the eccentric shaft rotates and causes the driving arm links to pivot about the cam shaft (Figure 5). The drive pawl located on the links engages with the ratchet wheel and rotates it, one tooth at a time. The ratchet wheel is prevented from rotating backward by a holding pawl, which is supported on links which project upward from the cam shaft.

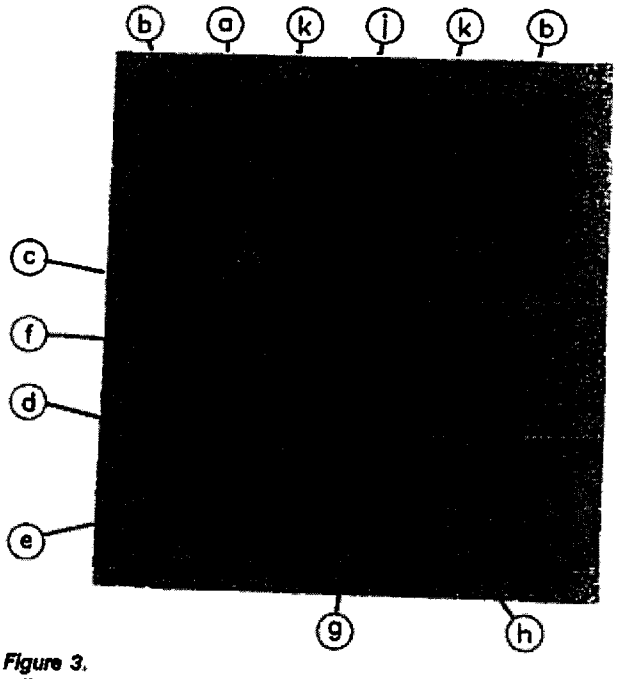


Figure 3.
Front View of POWL-VAC Circuit Breaker with Cover Removed

a. Anti-Pump Relay
b. Opening Spring
c. Shock Absorber
d. MOC Operating Arm
e. Auxiliary Switch
f. Shunt Trip Coil
g. Closing Coil
h. Charging Motor
j. Main Closing Spring
k. Connecting Rods

To insure correct synchronization of the drive and hold pawls, the hold pawl links are located by an adjustable eccentric stop located at the left front of the mechanism. When the mechanism is operated manually, the top pawl becomes the driving pawl and the bottom pawl becomes the holding pawl.

As the ratchet wheel is rotated, projections from its side faces will engage drive plates attached to the cam shaft and the cam shaft will rotate. Attached to the ends of the cam shaft are crank arms and pointing outward from these are crank pins. These engage with the bottom ends of the connecting rods (Figure 5), the top ends of which engage pins projecting from the spring compression plate which straddles

the main closing spring. As the cam shaft rotates, the connecting rods pull the spring compression plate downward, compressing the closing spring.

Figure 4. Charging Motor and Motor Cutoff Switch

a. Motor Cutoff Switch Assembly
b. Charging Motor

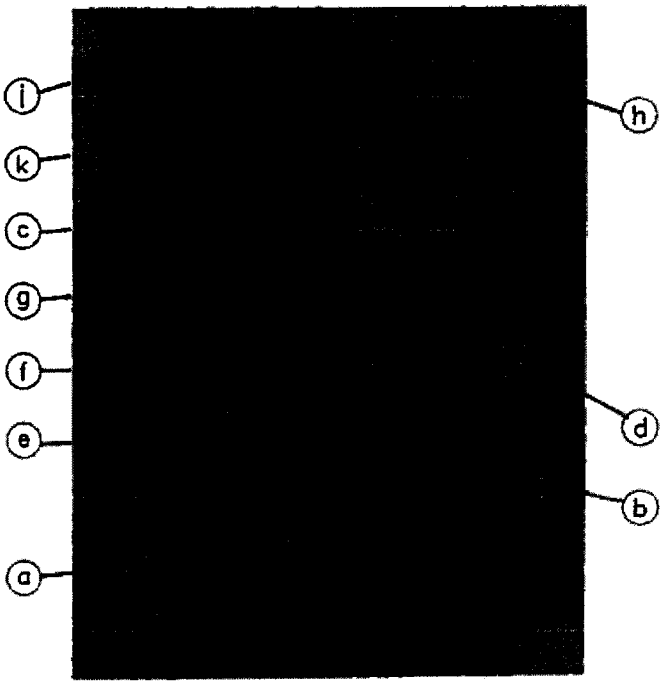


Figure 5. Main Operating Mechanism - Left Oblique View

a. Drive Pawl
b. Ratchet Wheel
c. Holding Pawl
d. Holding Pawl Adjusting Eccentric
e. Drive Plate
f. Crank Arm
g. Crank Pin
h. Secondary Trip Latch Adjusting Screw
j. Latch Check Switch
k. Connecting Rod

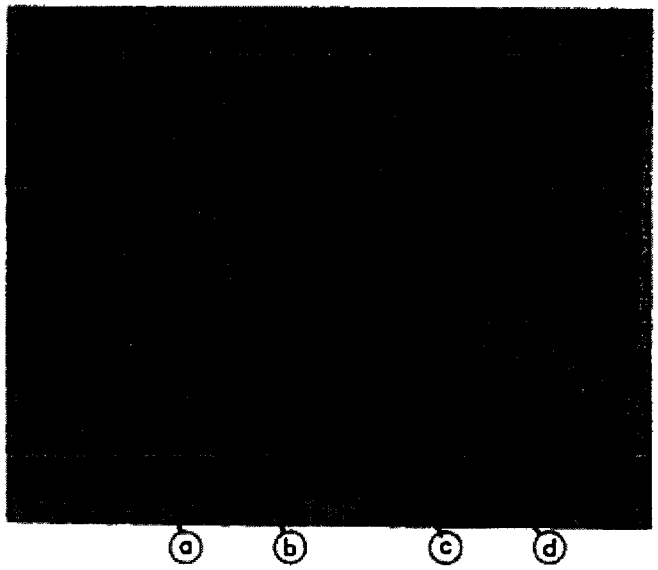


Figure 6. Main Operating Mechanism - Right Oblique View

a. Mechanism Reset Spring
b. Close Bar Adjusting Screw
c. Motor Cutoff Cam
d. Motor Cutoff Switch Operating Arm

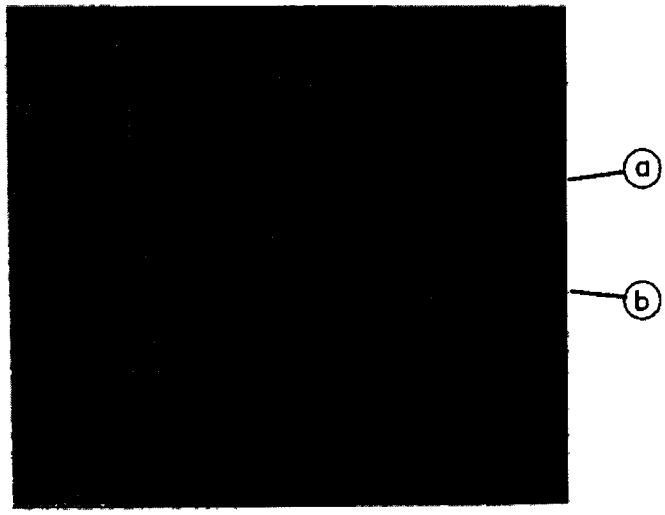
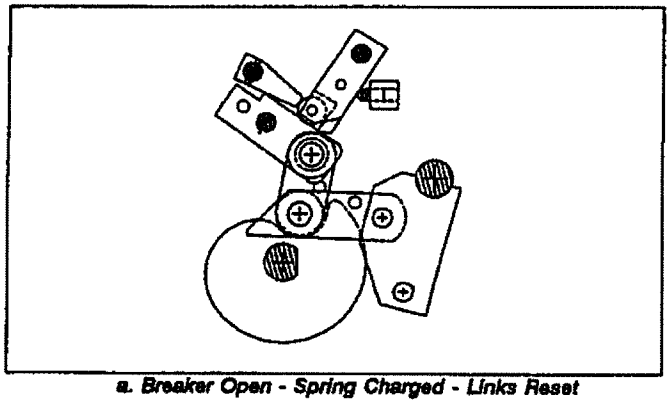


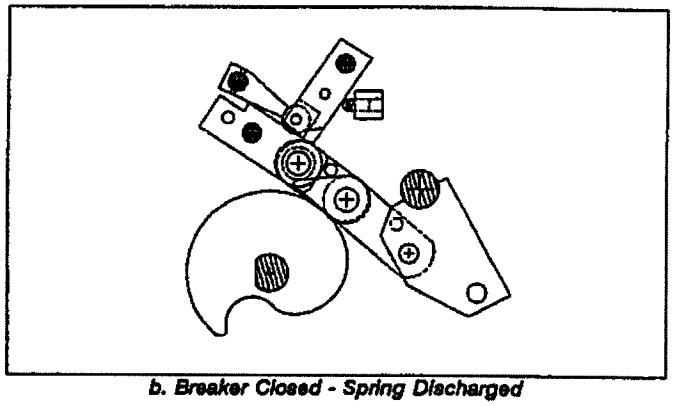
Figure 7. Close Latch Arm Engaging Close Latch Shaft

a. Close Latch Arm
b. Close Latch Shaft

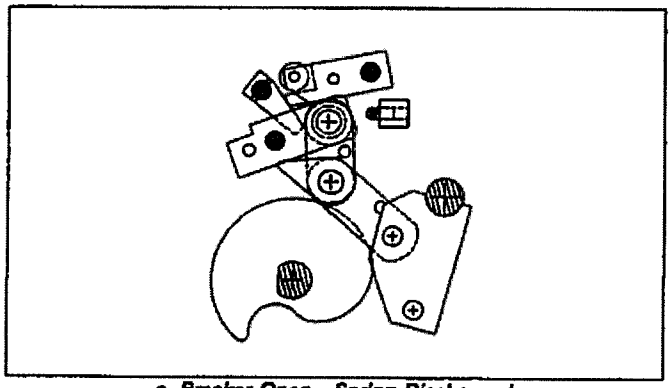
The ratchet wheel will drive the cam shaft so that the connecting rods go down to their lowest position and then start to move upward. At a certain point, the spring force will overcome friction and resistance and start to rotate the cam shaft. At the same time, the pawls are uncoupled from the ratchet wheel and the motor cutoff switch is operated. The motor cutoff switch located on the right of the mechanism is



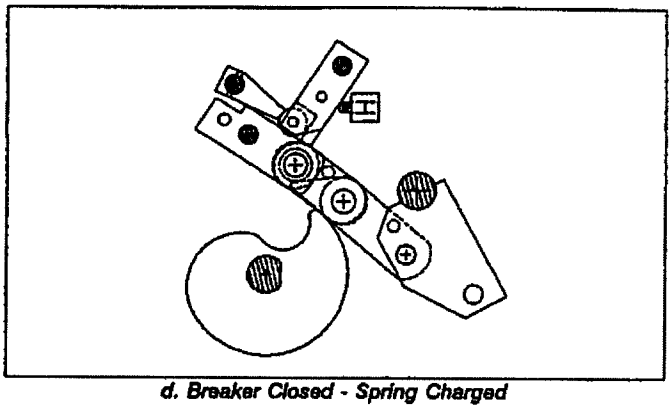
a. Breaker Open - Spring Charged - Links Reset



b. Breaker Closed - Spring Discharged



c. Breaker Open - Spring Discharged



d. Breaker Closed - Spring Charged

Figure 8. Cam and Fundamental Linkage Positions

operated by the spring charge flag falling into the spring charge cam (Figure 6). The spring charge flag will now show that the mechanism is charged. The cam shaft would continue to rotate, except that it is restrained by the close latch arm engaging against the close latch shaft (Figure 7). The main operating cam located between the mechanism side sheets is now in a position where the main drive linkage can move to the reset position (Figure 8a).

When the close latch is released, either under the action of the closing solenoid or the manual close plate, the closing spring pulls the cam shaft around, and the main closing cam moves the main linkage into the closed position. The main linkage rotates the center lever of the drive jack shaft. The jack shaft has 3 downward-pointing pairs of levers to which are attached the operating rods. The operating rods,which are approximately horizontal, are moved towards the vacuum interrupter by the rotation of the jack shaft (Figure 1, Page 2).

At the end of the operating rods remote from the jack shaft levers is a recess which encloses the contact loading springs. At the end of these springs, remote from the operating rod, is located the spring yoke which connects with the bell crank levers (Figure 9). The spring yoke is restrained by a lock nut on a stud which, passing through the contact loading spring, is attached to the operating rod. The contact loading spring has initial compression such that as soon as the vacuum interrupter contacts touch, they are loaded by a force sufficient to resist their separation under the highest electromagnetic forces exerted by the rated short circuit current.

Further movement of the operating rods compresses the contact loading spring even more and produces a gap between the face of the spring yoke and the lock nut. This gap will reduce as the vacuum interrupter contacts erode.

The bell crank levers, which are located on the outside of the bottom primary disconnect bars, are supported on a hinge pin bridging the bars and are connected to a drive pin which, passing through a slot in the disconnect bars, bridges the bell cranks and engages an extension to the vacuum interrupter moving stem. The bell cranks give an approximate 3 to 1 multiplication of the contact loading spring force which permits reduced spring force and enables a low rate spring to be used. They also multiply the contact movement of approximately 0.625 inch by a factor of 3 so that the mechanism linkages have relatively large movements and are less critical.

In the linkage positions shown in Figures 8b and 8d, the contact loading springs and the main opening springs are both acting to compress the three (3) main mechanism links (Figure 10).

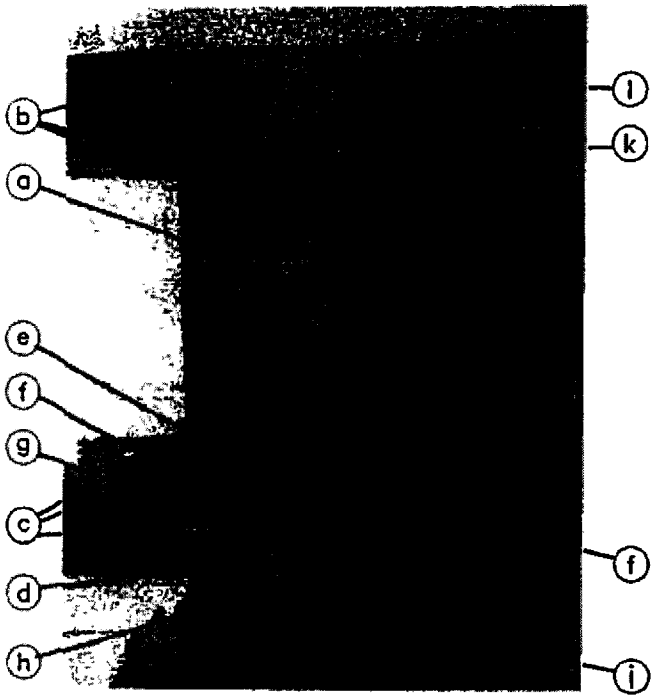


Figure 9. Interrupter and Operating Rod Mechanism

a. Interrupter
b. Upper Main Horizontal Primary Disconnect Bars
c. Lower Main Horizontal Primary Disconnect Bars
d. Operating Pin
e. Sliding contact Finger Assembly
f. Finger Holding Screws
g. Finger Assembly Mounting Clip
h. Bell Crank
j. Operating Rod
k. Upper Contact Block Bolts
l. Vertical Connector Bar Attachment Bolts

The linkage is restrained from movement by the secondary trip prop acting on the primary trip prop roller. The component of force tends to make the primary trip prop move upward, but it is restrained by the secondary trip prop face acting on the primary trip prop roller. The clearance between the primary trip prop roller and the secondary trip prop is controlled by the primary trip prop adjusting screw. When the trip shaft is rotated by the action of the manual trip plate or the electric trip solenoid, the secondary trip prop moves down and permits the primary trip prop to move upward, thus permitting the main linkage to move upward and the jack shaft to rotate, opening the breaker. The jack shaft extends from the left to the right side of the breaker frame and is supported at the main breaker frame side sheets and by the mechanism side sheets where it is clamped by hook plates. The two outer operating rod levers on the jack shaft have connections to the breaker opening springs (Figure 3). A projection of the left lever engages a shock absorber which controls the rebound of the interrupter contacts on opening operations. An extension of the jack shaft projects through the left breaker side sheet and operates the MOC switch drive.

With the standard electrical control scheme, as soon as the closing springs are discharged on a closing operation, the motor is switched on to recharge the springs. This leaves the main closing cam in a position where the tripped linkage can reset under the action of the reset spring (Figure 8d), and the primary and secondary trip props can fall into the reset position. The reset spring stretches between an extension of the main cam roller pin and a spring support pin located on the left mechanism side sheet. The trip latch check switch operated by a lever on the trip shaft will now close (Figure 5).

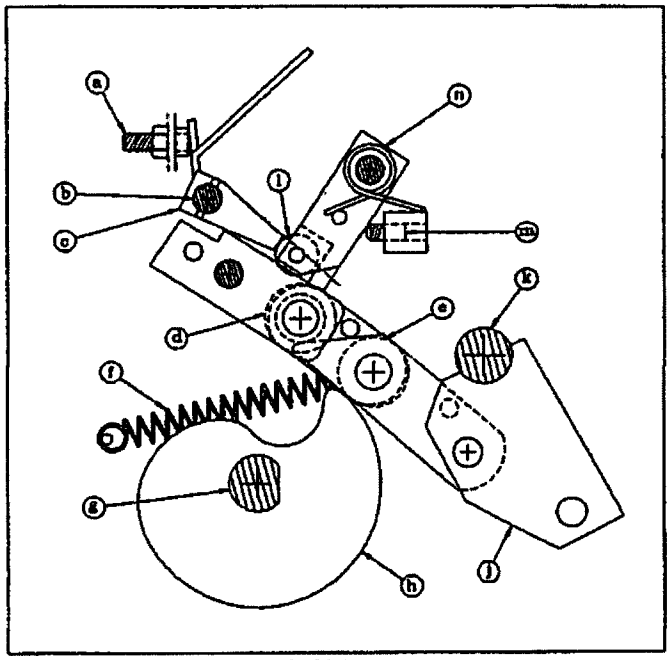


Figure 10. Mechanism and Trip Linkages

a. Secondary Trip Prop Adjusting Screw
b. Trip Bar
c. Secondary Trip Latch
d. Secondary Linkage Roller
e. Main Cam Roller
f. Reset Spring
g. Cam Shaft
h. Main Drive Cam
j. Center Phase Operating Lever
k. Main Jack Shaft
l. Primary Trip Prop Roller
m. Primary Trip Prop Adjusting Screw
n. Primary Trip Prop

C. LEVERING-IN DEVICE

The breaker is moved between the disconnected and connected positions by the levering-in device. This consists of a shaft which is supported by the breaker frame side sheets, and which has a crank arm at each end (Figure 1). Rollers attached to the crank arms engage vertical slots in plates attached to the cell and rotation of the shaft causes the breaker to move in and out of the breaker housing. The levering-in shaft supports a worm wheel at its right end just inside the right breaker side sheet (Figure 11). The worm wheel is rotated by a worm gear on a shaft which is terminated in a hexagon drive nut attached by a shear pin. The shaft points in a direction from the front to the back of the breaker. This hexagon shaft has a threaded portion carrying a threaded plate. As the shaft is rotated, the threaded plate moves along the worm shaft until it encounters either a front or a back sleeve attached to the shaft and further rotation of the worm shaft is prevented. At this time, the position indicator on the front of the breaker will indicate that the breaker is either in the connected or disconnected position. A socket-head bolt mounted on the left side sheet serves as a backup to the threaded plate, providing a positive stop to left crank arm.

Figure 11. Levering-In Mechanism and Interlocks

- *a. Levering-In Shaft (not shown)*
- *b. Worm Wheel*
- *c. Interlock Cam*
- *d. Worm Gear*
- *e. Interlock Plates*
- *f. Travelling Nut Plate*
- *g. Position Indicating Rod for Electrical Levering-In Device*
- *h. Access Shutter for Levering-In Drive Shaft*

D. INTERLOCKING

The first purpose of the interlocks is to insure that a breaker cannot be moved from the disconnected to the connected position unless the main breaker contacts are open and the secondary control circuitry from the compartment to the circuit breaker is completed.

The second purpose is to insure that the control circuits cannot be broken when the breaker is in the connected position and the breaker cannot be moved from the connected position unless its main contacts are first opened.

This interlocking is achieved by means of a shutter over the levering-in worm shaft and an interlock bar attached to the secondary disconnect plug.

Access to the hexagon drive nut on the levering-in device is restricted by a shutter on the front panel of the breaker (Figure 11). This shutter is pivoted on the breaker frame and has a projecting pin which engages a slot on a cam on the levering-in shaft. This particular cam has two (2) slots arranged so that the shutter can only be in its upward position when the levering in cranks are in the connected, test or disconnected position. The shutter cannot be moved downward until the trip plate is pushed inward and the secondary disconnect plug is inserted. Pushing the trip plate inward moves one prop out of the way of the shutter. Insertion of the secondary plug pushes the blocking plate backward and rotates a second prop out of the way of the shutter. Then, downward movement of the shutter causes a lever operating in parallel with the shutter to move downward, and a projecting pin on this lever disengages a second cam located next to the shutter cam. Downward movement of the lever moves a bolt which locks the secondary disconnect plug in its connected position. The second cam has only one slot and the lever can only move upward when the levering-in shaft is in the disconnected position. To summarize the action of the levering-in interlocks; the worm gear shaft shutter cannot be depressed until the breaker is tripped by pushing on the trip plate and the secondary disconnect plug is inserted. Downward movement of the shutter causes its interlock pin to move out of its cam plate. It also pushes a locking bolt downward to lock the secondary disconnect plug in position. The bolt cannot return upward in any other position than disconnect because it is restrained by a cam having only one slot.

E. SHUTTERS

In addition to moving the breaker in and out of the breaker connected position, the crank arm rollers sliding in the slots in the plates on the breaker housing operate the shutters over the primary disconnects in the switchgear cell. Downward movement of the rollers in the slots move the shutters before there is any movement of the breaker toward the connected position.

F. BREAKER POSITION INDICATORS

The breaker position indicator is visible through an opening in the front cover. The flags indicate whether the breaker is in the connected or the disconnected position.

When the "BREAKER CONNECTED" indicating arrow is opposite the center mark, the circuit breaker is in the fully connected position. Do not attempt to turn the levering-in crank further clockwise once this point is reached. Excessive force applied to the levering-in mechanism may result in damage to the equipment or injury to the operator. When the "BREAKER TEST/DISCONNECTED" indicating arrow is opposite the center mark, the circuit breaker is in the fully disconnected position, which is also the test position. Do not attempt to turn the levering-in crank further counter-clockwise once this point is reached. In positions other than the fully connected or disconnected, the position indicator does not give a reading (Figure 2).

G. VACUUM INTERRUPTER CONNECTIONS

Connection to the vacuum interrupter stems is made by means of hard copper blocks. The top stem of the interrupter is threaded, and a copper block is screwed onto this stem. This block is bolted to riser plates, which are in turn bolted to the upper primary disconnect arms of the circuit breaker. Another hard copper block is clamped to the bottom or moving stem of the vacuum interrupter. Bridge contacts make contact with this block and the lower primary disconnect arms. The multiple parallel paths of the bridge contacts keep the current density low.

H. OPERATING SOLENOIDS

The closing solenoid located under the middle of the mechanism is attached to the breaker floor pan by two screws accessible from underneath the breaker (Figure 3).

The shunt trip solenoid is to the left of the mechanism and is supported from the bottom frame channel (Figure 3).

Either a second shunt trip solenoid or an undervoltage trip device may be furnished as an option. When furnished, either of these devices is to the right of the mechanism and is supported from the bottom frame channel (Figure 12). Only one of these two auxiliary trip devices may be furnished on any one circuit breaker, as both types are located in the same space.

J. THE ANTI-PUMP RELAY

The anti-pump relay is located on the breaker frame to the left of the left connecting rod and is held by two screws (Figure 3).

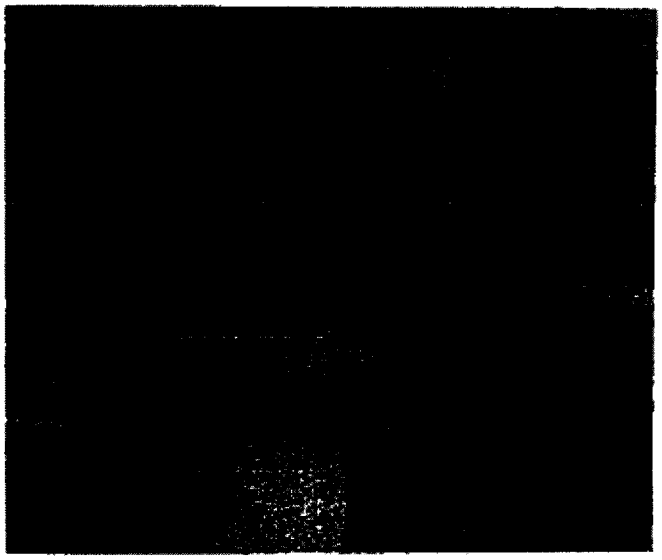


Figure 12. Shunt Trip Coil, Right

K. MOTOR CUTOFF SWITCH

The motor cutoff switch, which is located at the right of the mechanism, is attached to a bracket which is bolted to the breaker floor pan (Figure 4).

L. VACUUM INTERRUPTERS

All vacuum interrupters used in the circuit breakers covered by this instruction book are the same size and appearance, but different ratings differ in their internal construction. Each vacuum interrupter bears a label to indicate its part number. Vacuum interrupters must be replaced only with new interrupters of the same part number.

M. SECONDARY DISCONNECT PLUG

Control power is transferred from the switchgear to the circuit breaker by means of the secondary disconnect plug and umbilical cord attached to the switchgear. This arrangement makes the secondary connection visible in all positions of the circuit breaker.

IV. INSTALLATION

A. RECEIVING

Figure 13 shows the breaker enclosed in the carton used for shipment. Check for signs of damage. If damage is found or suspected, file claims as soon as possible with the transportation company, and notify the nearest representative of Powell Electrical Manufacturing Co.

Figure 13. Circuit Breaker in Shipping Carton

The carton is attached to the shipping skid by two metal bands. Remove these bands and lift the carton off the circuit breaker. The breaker is attached to the skid by two more metal bands. When these are removed, the breaker may be removed from the shipping skid.

In some switchgear equipment, circuit breakers located in lower cells may be shipped in the switchgear, unpacked. The breaker will be in the disconnected position. It will be bolted to the cell floor by use of a shipping angle. The horizontal leg of this angle is bolted to the cell floor, using two cell tie-down bolts, and the vertical leg is bolted to the front of the circuit breaker using the two lower cover mounting bolts (Figure 14). Remove these four bolts, discard the shipping angle, and replace the four bolts.

B. HANDLING

The breaker can be handled by a fork lift truck if care is taken to avoid components located under the breaker floor pan. These components are the breaker coding plate and the

Figure 14. Circuit Breaker Bolted to Equipment Floor for Shipment

ground contact. The forks on the truck should be set for a dimension over the forks of 28 inches. The forks should then ride under the wheel axles (Figure 15). The breaker can be lifted by an overhead crane using holes which have been provided for hooks at the top of the breaker frame side sheets (Figure 16).

C. STORAGE

It is recommended that the breaker be put into service immediately in its permanent location. If this is not possible, the following precautions must be taken to assure the proper storage of the breaker:

(1) The breaker should be carefully protected against condensation, preferably by storing it in a warm dry room of moderate temperature, such as 40°-100°F, since dampness has an adverse effect on the insulating parts. Circuit breakers for outdoor metal-clad switchgear should be stored in the equipment only when power is available and the heaters are in operation to prevent condensation.
(2) The breaker should be stored in a clean location, free from corrosive gases or fumes. Particular care should be taken to protect the equipment from moisture and cement dust, as this combination has a very corrosive effect on many parts.
(3) Unplated surfaces of rollers, latches, etc., of the operating mechanism should be coated with grease to prevent rusting.

If the breaker is stored for any length of time, it should be inspected periodically to see that rusting has not started and to insure good mechanical condition. Should the breaker be stored under unfavorable atmospheric conditions, it should be cleaned and dried out before being placed in service.

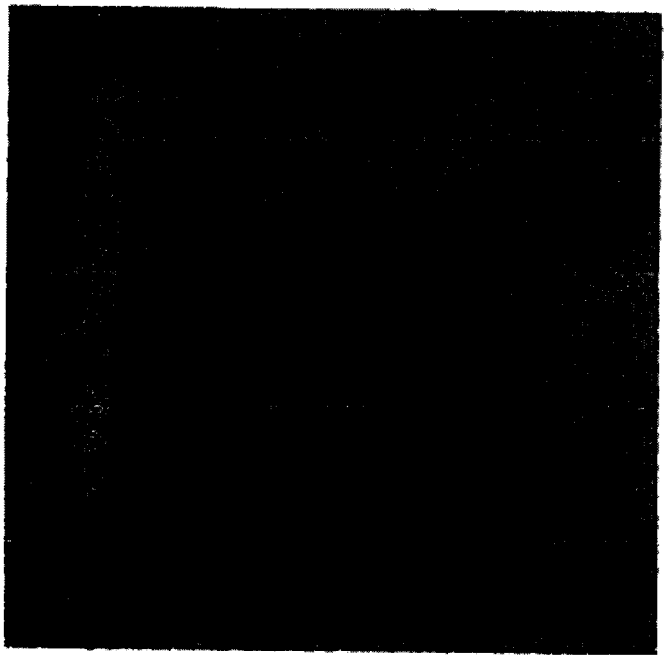


Figure 15. Circuit Breaker Being Lifted by Fork Truck

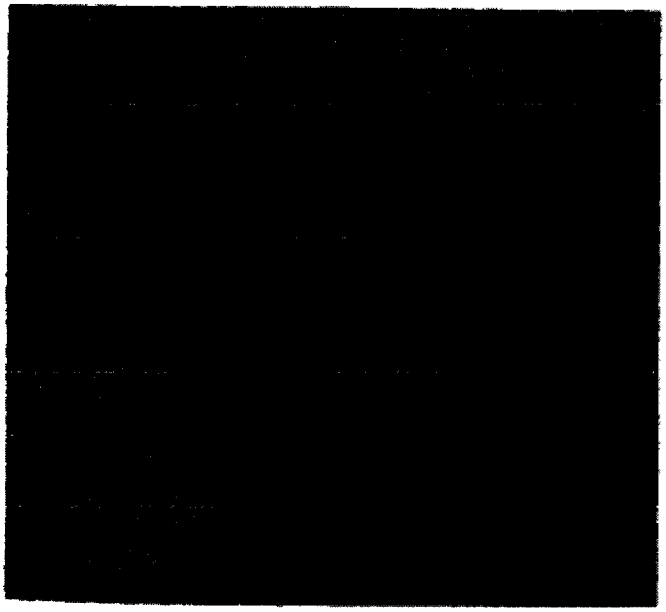


Figure 16. Circuit Breaker Being Lifted on Crane

D. PUTTING INTO SERVICE

Before shipment from our factory, all breaker functions will have been thoroughly checked. If the user wishes to recheck the operation, we recommend that the check be performed in the sequence listed below:

(1) High voltage insulation integrity.
(2) Vacuum integrity in the interrupters.
(3) Control voltage insulation integrity.
(4) Mechanical operation of the mechanism.
(5) Electrical operation of the mechanism.
(6) Levering-in device

CAUTION

High voltage across the open gaps of the interrupter can produce radiation. Personnel should stand at least 1 meter (39 inches) away from the breaker, in front of the front cover, when conducting high voltage tests. Test voltage should not exceed 38kV, 50 or 60 Hz, or 50kV dc.

(1) High Voltage Insulation Integrity

To check insulation integrity, the AC high potential test described below is strongly recommended. DC high potential testing is not recommended except for the Vacuum Interrupter Integrity Test.

Caution: If DC high potential testing is required, the DC high potential test machine must not produce peak voltages exceeding 50kV.

The circuit breaker insulation should be tested with the circuit breaker in the "CLOSED" position. Test each pole of the breaker separately, with the other 2 poles grounded. Perform the one minute low frequency withstand test described in ANSI Standard C37.20.2-1987, 5.2.1 and 5.2.1.1, at the voltage level appropriate for the equipment, 14kV for circuit breakers rated 4.16kV or 27kV for circuit breakers rated 13.8kV.

This test will have checked all of the support insulators, and also the primary phase-to-phase insulation.

Caution: Remove all grounding conductors applied for this test before placing the breaker back into service.

(2) Vacuum Integrity

Vacuum interrupters used in Powl-Vac circuit breakers are highly reliable interrupting elements. Satisfactory performance of these devices is primarily dependent upon the integrity of the vacuum in the chamber and internal dielectric strength. Both these parameters can be readily checked by a high

potential test.

CAUTION

APPLYING ABNORMALLY HIGH VOLTAGE ACROSS A PAIR OF CONTACTS IN VACUUM MAY PRODUCE X-RADIATION. THE RADIATION MAY INCREASE WITH THE INCREASE IN VOLTAGE AND/OR DECREASE IN CONTACT SPACING.

X-RADIATION PRODUCED DURING THIS TEST WITH RECOMMENDED VOLTAGE AND NORMAL CONTACT SPACING IS EXTREMELY LOW AND WELL BELOW MAXIMUM PERMITTED BY STANDARDS. HOWEVER, AS A PRECAUTIONARY MEASURE AGAINST POSSIBILITY OF APPLICATION OF HIGHER THAN RECOMMENDED VOLTAGE AND/OR BELOW NORMAL CONTACT SPACING, IT IS RECOMMENDED THAT ALL OPERATING PERSONNEL STAND AT LEAST ONE METER AWAY IN FRONT OF THE BREAKER.

DO NOT APPLY VOLTAGE THAT IS HIGHER THAN THE RECOMMENDED VALUE. DO NOT USE CONTACT SEPARATION THAT IS LESS THAN THE NORMAL OPEN POSITION SEPARATION OF THE BREAKER CONTACTS.

The test of the vacuum interrupter will determine its internal dielectric condition and vacuum integrity. With the breaker open and removed from the cell, apply the high potential across each interrupter separately. It is recommended that the interphase barriers be in place during this test to prevent phase-to-phase breakdown. Connect the "hot" lead of the test source to the upper stud of the pole under test and the ground lead to the lower stud. If the test supply is center-point grounded, the connections may be made either way. Apply 36kV rms 60 Hz or 50kV dc and hold for a minimum of five (5) seconds. If no breakdown occurs the interrupter is in acceptable condition. If a breakdown occurs the interrupter should be replaced.

CAUTION

WHEN TESTING WITH DC, USE A DC HIGH POTENTIAL TEST SET WITH FULL WAVE RECTIFICATION. MANY DC HIGH POTENTIAL TEST SETS USE HALF-WAVE RECTIFICATION. DO NOT USE THESE HALF-WAVE RECTIFIERS. THE CAPACITANCE OF THE VACUUM INTERRUPTER IN COMBINATION WITH THE LEAKAGE CURRENTS IN THE RECTIFIER AND ITS DC VOLTAGE MEASURING EQUIPMENT MAY RESULT IN APPLYING PEAK VOLTAGES AS MUCH AS THREE TIMES THE MEASURED VOLTAGE. THESE ABNORMALLY HIGH VOLTAGES MAY GIVE A FALSE INDICATION OF A DEFECTIVE INTERRUPTER, AND MAY PRODUCE ABNORMAL X-RADIATION.

No attempt should be made to try to compare the condition of one vacuum interrupter with another nor to correlate the condition of any interrupter with low values of dc leakage current. There is no significant correlation.

After the test potential is removed, discharge any electrical charge that may be retained.

(3) Control Voltage Insulation Integrity

If the user wishes to check the insulation integrity of the control circuit, it may be done with a 500 volt or 1000 volt insulation tester or with an ac high potential tester. The ac high potential test should be made at 1125 volts, 60 Hz, for one minute. The charging motor must be disconnected at its connection plug prior to testing the control circuit. The motor itself may be similarly tested at a voltage not to exceed 675 volts, 60 Hz. Be sure to remove any test jumpers and reconnect the charging motor when the tests are complete.

(4) Mechanical Operation Check

In normal operation, the contacts of the vacuum interrupters cannot be closed unless the secondary disconnect plug is in position. To check the breaker outside of the

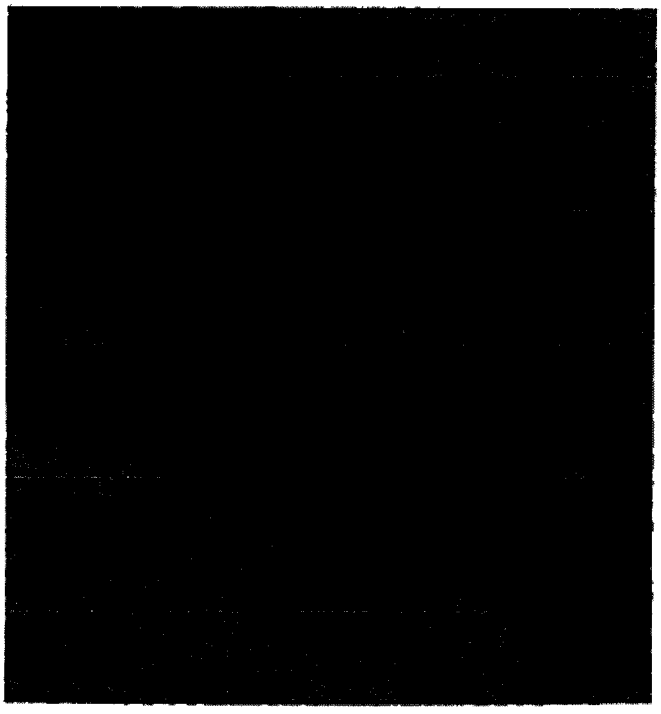


Figure 17. Circuit Breaker with Secondary Test Connector in Place

compartment, it is necessary to simulate the connection of secondaries by inserting the secondary test connector in the slot below the fixed secondary contacts (Figure 17). This device must be removed after testing and before the breaker is inserted into the cell. An interference plate will deter insertion of the circuit breaker into the cell with the test connector in place. The manual charge lever should now be inserted into the manual charge crank and pushed down until a metallic click is heard. This indicates that the holding pawl has dropped into place on the ratchet wheel. Lift the lever until it is horizontal and then depress. The procedure is repeated until the spring charge flag indicates that the close spring is now charged. This requires about 60 operations of the handle. Remove the handle. Push the round blue "PUSH TO CLOSE" plate and the breaker will close. The flag located above the "PUSH TO CLOSE" plate will now read "CLOSED". Push the round red trip plate located at the top of the escutcheon and the breaker will open as indicated by the breaker condition flag.

(5) Electrical Operation

To check the electrical operation of the breaker, a jumper cable must be used. First, remove the control fuses in the compartment. Connect the jumper cable to the umbilical cord in the compartment and to the breaker. Insert the fuses. The motor mechanism will automatically charge the stored energy closing springs. Operation of the closing switch on the front door of the compartment will cause the breaker to close. The circuitry is arranged to cause the motor to operate again and charge the closing spring. Operating the electrical trip switch on the front door will cause the breaker to open. Alternately, the breaker may be connected to a test cabinet to perform these functions.

(6) Levering-In Device

With the breaker removed from the cell and the secondary test connector in place, the operation of the levering-in device is checked by first pushing the trip plate and moving the levering-in shutter downward to give access to the 0.75" hexagon worm shaft. It should be noted that this shutter cannot be moved downward unless the trip plate is pressed to insure an open breaker and the secondary connector or secondary test connector is inserted. Insert the levering-in crank provided or a standard 3/4 inch socket onto the hex shaft. The levering-in crank arms at the side of the breaker should point in the direction of the main disconnects and the position indicators on the front cover should indicate "DISCONNECTED". Rotate the hex worm shaft in a clockwise direction. The crank arms will move downward and rotate until the position indicator reads "CONNECTED". Further rotation of the hex shaft is prevented by a threaded plate moving on a threaded portion of the hex shaft. Once the indicator reads "CONNECTED" and indicating arrow is opposite to the central indication mark, the levering-in mechanism will have reached the end of its travel and it will be obvious by the amount of resistance that further force should not be exerted. In this position, it is possible to remove the socket from the shutter aperture and the shutter will spring back to the closed position. It will not be possible to remove the secondary test connector.

Once again, push the trip plate, depress the levering-in shutter, insert the crank or socket and rotate in a counter-clockwise direction until the levering-in cranks are once more in the fully withdrawn position and the indicator indicates "DISCONNECTED". With the crank arms in this position, it will be possible to remove the secondary test connector.

The above procedure will have checked out the levering-in device and its associated interlocks.

E. INSERTING BREAKER INTO SWITCHGEAR EQUIPMENT

Refer to the metal-clad switchgear instruction book for general information and cautions before attempting to insert a circuit breaker into the switchgear equipment. Be sure that the levering-in crank arms at the sides of the breaker point in the direction of the main disconnects and the position indicator reads "DISCONNECTED".

Each circuit breaker and each cell is provided with a coding plate designed to ensure that no breaker with less than the required voltage, continuous current or interrupting current rating is placed in any cell. If you attempt to insert an improperly rated breaker into a cell, these coding plates will interfere with each other and deter the insertion. The interference will occur before the breaker reaches the disconnect position. DO NOT attempt to force the breaker past this interference or remove the coding plate from either the cell or the breaker. Remove the incorrectly rated breaker and insert the proper breaker.

To insert a breaker into a lower compartment, first align the wheels with the housing floor pan channels. Then roll the breaker into the housing until the levering-in arms contact the levering-in cam plates in the cell. At this point, the rollout latch on the lower right side of the breaker will have engaged the stop in the cell, deterring removal of the breaker from the cell.

To insert a breaker into an upper cell, a lift truck is required. A detailed procedure for this operation is described in the instruction book for the metal-clad switchgear equipment, IB-51000.

To move the circuit breaker to the "CONNECTED" position, first plug in the secondary disconnect device into the circuit breaker. Then push in the trip plate and move the levering-in shutter down. Insert the levering-in crank onto the hex shaft and rotate the crank clockwise. When the breaker is being inserted into the compartment, the force needed to rotate the crank will be low at the beginning of motion when movement of the crank arms is only opening the shutters; however, as the

breaker moves into the compartment, the breaker main disconnect contacts will engage the fixed stabs located in the spouts and the force required to rotate the crank will increase appreciably. This is normal and as soon as the contacts are fully engaged, this force will decrease. Further rotation of the crank will cause the breaker to move further into the compartment ensuring wipe or overlap of the main disconnect contact and rotation of the crank clockwise can continue until the indicator flag reads "CONNECTED". At this point, DO NOT attempt to rotate the crank clockwise further or damage to the mechanism could occur. Once the breaker has reached the "CONNECTED" position, remove the levering-in crank and allow the levering-in shutter to return to its normal closed position. The circuit breaker is now ready for service.

The maximum force required on the levering-in crank for normal insertion of a circuit breaker will not exceed 65 lbs. Excessive force may damage the circuit breaker or the switchgear equipment.

To move a circuit breaker from the "CONNECTED" position to the "DISCONNECTED" position, first trip the circuit breaker. Then push in the trip plate, move the levering-in shutter down, and insert the levering-in crank. Rotate the crank counter-clockwise until the indicator flag reads "TEST/DISCONNECTED". At this point, DO NOT attempt to rotate the crank further counter-clockwise or damage to the mechanism could occur. The circuit breaker is now in the "TEST" position and may be operated electrically to test the operation of the breaker and/or its control circuits without completing the primary circuit.

To remove a circuit breaker from its cell, pull out the secondary disconnect plug and stow it on the clip provided in the cell. Removing this plug will cause the closing springs to discharge. If the breaker is in a lower cell, depress the rollout latch handle at the lower right side of the breaker so that the latch clears the stop on the housing floor plan channel. Then roll the breaker out onto the floor. If the breaker is in an upper cell, refer to instruction book IB-51000 for the metal-clad switchgear equipment for a detailed procedure for removing it.

F. POWER RACKING DEVICE

A motor-driven racking device is available as an optional accessory (Figure 18). When furnished, it is used as follows:

To connect the breaker

Insure that breaker is fully inserted into cell and that levering-in crank arms are in correct position relative to hook plates. Remove 1/4-20 cover bolt from right side of front cover (Figure 2). Open levering-in access shutter by first pushing breaker trip plate and then moving shutter downward. Insert power racking adaptor sleeve (Figure 19) onto hexagonal racking shaft. Grasp the power racking device by the top lifting rod and place over the right portion of the front cover top flange (Figure 20) so that the hook portion of the racking device matches the cutout at the back of the flange. The

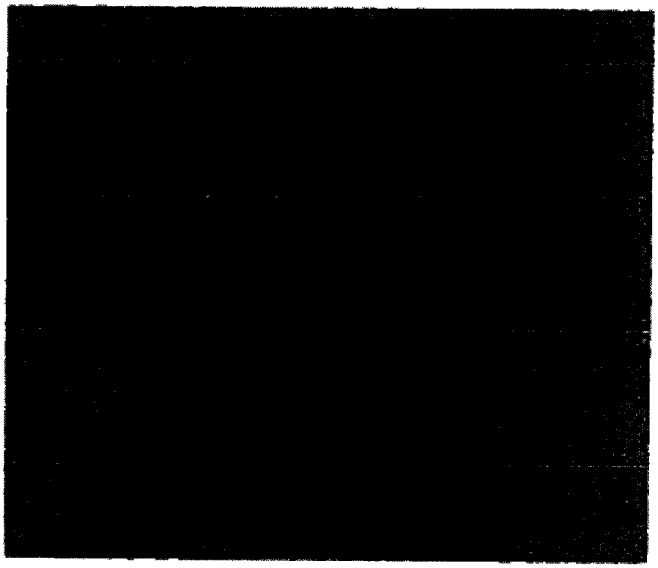


Figure 18. Power Racking Device

Figure 19. Power Racking Device Adapter on Levering-In Shaft

racking device can now swing downward and the locking screw can be inserted into the hole from which the front cover holding screw was previously removed. Finger tighten the screw so that the racking device is flush with the breaker front cover (Figure 21). The extension cable of the racking device can now be extended so that the control box is in the required operating location. A 25 ft. length of cable is supplied as standard. The control box needs a 120 V ac supply to operate the racking device. To insert the breaker, switch the two position control switch to the "in" position and push the switch downward. The breaker will commence its movement into the

breaker connected position and the movement will automatically cease when the breaker is fully connected. To remove the power racking device, first remove the power supply to the control box and then unscrew the locking screw on the front of the power racking device. The device can then be lifted off the breaker front cover by swinging the bottom end away from the cover and lifting the device over the flange of the breaker cover.

Figure 20. Placing Power Racking Device on Circuit Breaker

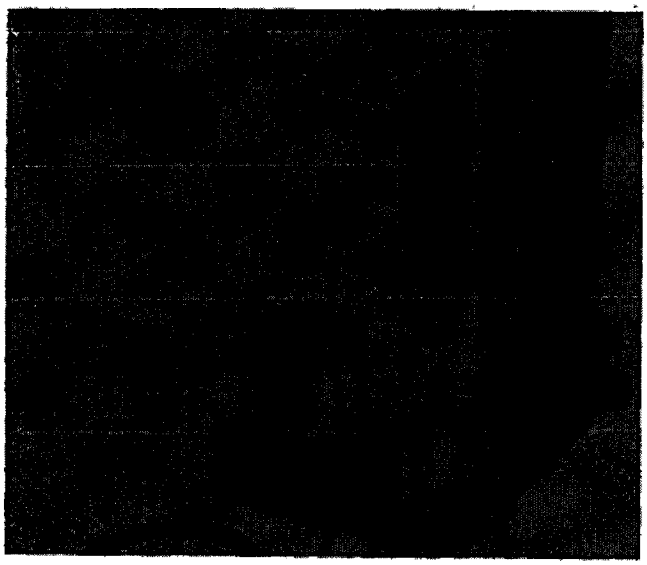


Figure 21. Power Racking Device in Place on Circuit Breaker

To operate the breaker, the power racking adaptor sleeve must be removed to permit the shutter to move upward thus removing the trip safety feature from the mechanism. Replace the adaptor sleeve in its mounting clip on the side of the power racking device and replace the cover screw. The breaker is now ready for normal operation.

To remove the breaker

Use the same procedure as for connecting the breaker, except the power racking remote control switch should be switched to the "out" position before pushing the switch downward. The motor will automatically stop when the breaker is fully withdrawn.

Caution: If the control switch is not held down until the breaker is either fully connected or fully withdrawn and the power racking device is removed, operation of the breaker will not be possible because the levering-in shutter will not return to its "up" position releasing the trip safety interlock.

V. MAINTENANCE

Contact Powell Apparatus Service Division for assistance in performing maintenance or setting up a maintenance program.

A. GENERAL

(1) Introduction

A regular maintenance schedule should be established to obtain the best service and reliability from the circuit breaker. Powl-Vac circuit breakers are designed to comply with industry standards requiring maintenance every 2000 operations or once a year, whichever comes first.

Actual inspection and maintenance will depend upon individual application conditions such as number of operations, magnitude of currents switched, desired overall system reliability and operating environment. Any time the breaker is known to have interrupted a fault current at or near its rating it is recommended that the breaker be inspected and necessary maintenance be performed as soon as is practical. Some atmospheric conditions such as extremes of dust and moisture or corrosive gases might indicate inspection and maintenance at more frequent intervals than 2000 operations. Very clean and dry conditions combined with low switching duty will justify longer times between inspection and maintenance operations. With experience, each user can set an inspection and maintenance schedule which is best suited for the particular use.

A permanent record of all maintenance work should be kept, the degree of detail depending on the operating conditions. In any event, it will be a valuable reference for subsequent maintenance work and for station operation. It is recommended that the record include reports of tests made, the condition of breakers and repairs and adjustments that

were made. This record should begin with any checks done at the time of installation and energization.

Because of extensive quality control checks made at the factory, the operations counter on a new circuit breaker will normally register over a hundred operations. The actual reading of the operations counter should be recorded when the circuit breaker is put into service and whenever any maintenance is performed.

Before attempting any maintenance work, take note of safety practices outlined in Section II of this book.

MAKE CERTAIN THAT THE CONTROL CIRCUITS ARE DE-ENERGIZED AND THE BREAKER IS RESTING SECURELY OUTSIDE THE SWITCHGEAR HOUSING. DO NOT WORK ON A CLOSED BREAKER OR A BREAKER WITH THE CLOSING SPRINGS CHARGED.

(2) Inspection and Cleaning

Give the breaker a visual check for loose or damaged parts. Tighten or replace loose or missing hardware. Any part damaged so as to interfere with normal operation of the circuit breaker should be replaced. This inspection will be much easier if the front cover and interphase barrier assembly are removed.

Clean the breaker, removing loose dust and dirt. Do not use an air hose to blow the breaker out; this may result in loose dirt or grit being blown into bearings or other critical parts and causing excessive wear. Either use a vacuum cleaner or wipe with a dry lint-free cloth or an industrial-type wiper.

Primary insulation, including the interrupter supports and the operating rods, should be cleaned also. Wipe clean with a dry lint-free cloth or an industrial type wiper. If dirt adheres and will not come off by wiping, remove it with distilled water or a mild solvent such as denatured alcohol. Be sure that the breaker is dry before returning it to service. Do not use any type of detergent to wash the surface of the insulators, as detergent may leave an electrical conducting residue on the surface as it dries.

B. MECHANISM AREA

(1) Mechanical Operation

Remove the circuit breaker front cover, exposing the mechanism. Make a careful visual inspection of the mechanism for loose, damaged or excessively worn parts. Operate the breaker several times manually.

Operate the levering-in mechanism through one or two complete cycles and check for smoothness of operation. It will be necessary to insert the secondary test connector into the secondary disconnect receptacle to perform this operation.

See the sections headed "Mechanical Operation Checks" and "Levering-in Device" under the heading PUTTING INTO SERVICE for further information.

(2) Lubrication

Lubricate the mechanism and other specified parts in accordance with the lubrication chart, Table I, Page 16.

The chart shows the location of all surfaces which should be lubricated together with the type of lubricant and method of application. The guiding rule in lubrication should be to lubricate regularly, use lubricant sparingly and remove all excess lubricant.

Anderol 757 Grease should be lightly applied to those bearing surfaces which are accessible and a light synthetic machine oil such as Mobil 1 should be used to penetrate through to surfaces which are inaccessible. The mechanism should be in the open, spring discharged position for lubrication. There is no necessity to disassemble the mechanism for lubrication. Tilting the breaker will facilitate the entry of the lubricant to the bearing surfaces.

(3) Closing Spring Removal and Slow Closing of Mechanism

Disassembly of the mechanism is not required for routine lubrication; however, for major overhaul, removal of the closing spring is necessary. Removal of the spring permits slow closing of the vacuum interrupter contacts. The procedure for spring removal is as follows:

With closing spring discharged and breaker contacts open, remove the screw at the top of the spring rod together with the flat washer and lock washer. Remove the right-angle bracket by unfastening the two attachment screws. Remove the spacer from below the bracket. Turn the bracket 90° and replace it on top of the spring yoke. Place the spacer on top of the bracket with the flat washer above it. Insert screw and screw down until tension is taken off the connecting rods (Figure 22). The connecting rods can now be unhooked from the spring yoke pins and the spring assembly removed. Care should be taken on reassembly to insure correct location of the flat washer, lock washer and spacer. See Figure 23.

With the main spring assembly removed, rotate the cam shaft so that the crank arms are pointing downward. The main linkage will now move into the reset position. Push the "PUSH TO CLOSE" plate and hold in while operating the hand charge lever to rotate the cam shaft. Once the close release latch arm is past the close shaft latch plate, the "PUSH TO CLOSE" plate may be released. As the main cam engages the main linkage

Table I. Circuit Breaker Lubrication

Location	Lubricant	Method
Electrical Parts		
Main Primary Disconnect Fingers	Mobilgrease 28	Wipe clean. Apply lubricant only to actual contact surface.
Sliding Contact Blocks	Mobilgrease 28	With breaker closed, wipe clean and apply thin smear of lube above sliding contact fingers.
Mechanical Parts		
Levering-In Device Worm and Wheel	Anderol 757 Grease	Feed grease between worm and wheel while rotating worm shaft between disconnected and connected positions.
Worm Shaft Bearings	Mobil 1 Machine Oil	
Levering-In Shaft Support Bearings	Mobil 1 Machine Oil	
Levering-In Crank Arm Rollers	Mobil 1 Machine Oil	Tilt dummy breaker sideways and rotate roller while lubricating.
Wheels	Mobil 1 Machine Oil	Tilt dummy breaker sideways and rotate wheels while lubricating.
Camshaft Camshaft Needle Bearings	Mobil 1 Machine Oil	
Crank Pins	Mobil 1 Machine Oil	
Spring Yoke Pins	Mobil 1 Machine Oil	
Rachet Wheel	Mobil 1 Machine Oil	
Pawls	Mobil 1 Machine Oil	
Oscillator Arms at Camshaft	Mobil 1 Machine Oil	
Jackshaft Lever Pins Passing Through Push Rods	Mobil 1 Machine Oil	Avoid lubricant on push rods.
Main Spring Guide Rod	Mobil 1 Machine Oil	
Motor Drive Shaft Support Bearing	Mobil 1 Machine Oil	
Motor Drive Shaft Roller Needle Bearings	Mobil 1 Machine Oil	
Motor Drive Shaft Coupler Recess	Mobil 1 Machine Oil	
Trip Shaft Support Bearings	Mobil 1 Machine Oil	
Close Shaft Support Bearings	Mobil 1 Machine Oil	
Close Shaft Latch Face	Anderol 757 Grease	Apply light coating of grease and remove all excess.
Primary Trip Prop Shaft Support Bearings	Mobil 1 Machine Oil	
Primary Trip Prop Shaft Roller	Mobil 1 Machine Oil	
Main Linkage	Mobil 1 Machine Oil	Apply to penetrate where pins pass through links.
Fixed Link Pin	Mobil 1 Machine Oil	Apply to penetrate where pin passes through end link.
Motor Drive Shaft Roller Needle Bearings	Mobil 1 Machine Oil	
Jackshaft Outer Bearing Supports	Mobil 1 Machine Oil	
Jackshaft Supports at Mechanism	Mobil 1 Machine Oil	
Open-Closed Flag Drive Lever at Jackshaft	Mobil 1 Machine Oil	
Motor Cutoff Switch Cam	Anderol 757 Grease	Apply to peripheral surface only.
Flag Support Pins	Mobil 1 Machine Oil	

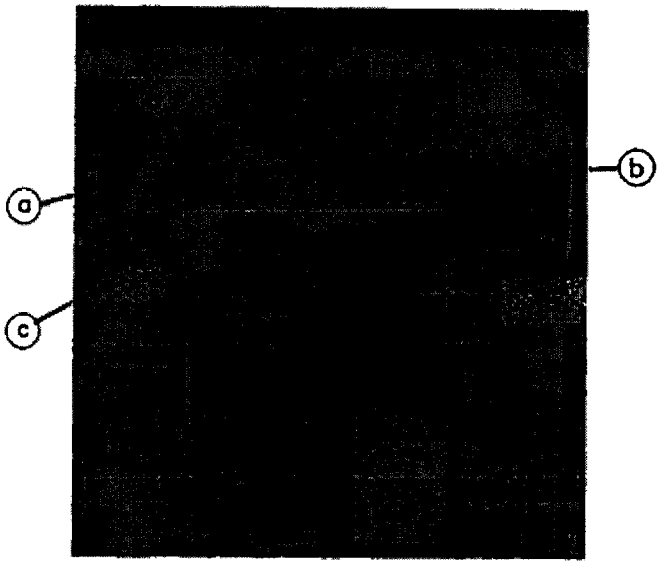


Figure 22. Main Closing Spring Assembly Compressed for Removal

- *a. Bracket*
- *b. Flat Washer*
- *c. Screw*

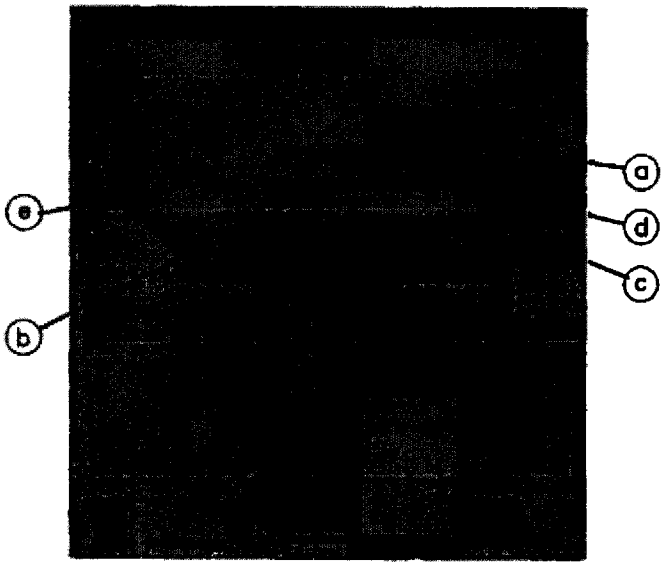


Figure 23. Main Closing Spring Assembly Installed

- *a. Bracket*
- *b. Spacer*
- *c. Flat Washer*
- *d. Screw*
- *e. Lock Washer*

roller, the jackshaft will commence to rotate. Continue to operate the hand charge lever until the crank arms point upward. The breaker will now be closed and there will be a gap between the contact overtravel nuts and the contact spring yokes. See Figure 25.

(4) Mechanism Adjustments

Several factory adjustments in the mechanism are described below. No adjustment of these settings is required for routine maintenance, but they may need to be adjusted after major overhaul or removal of the mechanism. DO NOT ADJUST THESE SETTINGS UNNECESSARILY.

A. Adjustment of Ratchet Wheel Holding Pawl

The ratchet wheel holding pawl (c, Figure 5, Page 4) is adjusted by an eccentric cam (d, Figure 5, Page 4). If the pawl is not properly adjusted, there will be a "knocking" noise when the ratcheting mechanism is operating, or the mechanism will not ratchet at all. To adjust the pawl, remove the escutcheon to gain access to the head of the bolt holding the eccentric cam. Loosen the bolt slightly. While charging the spring using the charging motor to drive the mechanism, grip the eccentric cam with a pair of slip-joint pliers or a similar tool and rotate the cam slightly until the ratcheting operation is smooth. This may require several charging cycles, as each charging cycle lasts only a few seconds. When the eccentric cam is properly set, re-tighten the mounting bolt and replace the escutcheon. Be sure that the escutcheon is reinstalled on the proper circuit breaker, since the escutcheon contains the nameplate with all the breaker's rating and serial number information.

B. Adjustment of Primary and Secondary Trip Latches and Latch Check Switch

Adjust the secondary trip latch adjusting screw (h, Figure 5, Page 4) so that the overlap of the secondary trip prop on the primary trip prop roller is approximately .125 inch (Figure 10, Page 6). Adjust the primary trip latch adjusting screw (Figure 10) so that with the main linkage in the reset position the clearance between the primary trip latch roller and the secondary trip prop is 0.030 inch. The primary trip latch adjusting screw is accessible from the rear of the mechanism, between the legs of the lower center phase support insulator (Figure 24). With an 0.030 inch wire gauge between the trip bar lever and the secondary trip latch adjusting screw, the latch check switch should be open. With no gap between the lever and the screw, the latch check switch should be closed.

C. Adjustment of Close Latch

The close shaft passes through the side sheets of the mechanism frame at the front of and below the cam shaft. The left end of the shaft is shaped to make a latch face and interferes with the latch arm which is fixed to the cam shaft (Figure 7, Page 5). The other end of the close shaft is on the right side of the mechanism and a small lever attached to it is positioned by an adjusting screw (b, Figure 6, Page 4). With the main closing spring charged, turn the latch adjusting screw inward toward the rear of the breaker until the latch is released and the breaker closes. Unscrew the adjustment screw 2½ turns and lock in position with the locking nut.

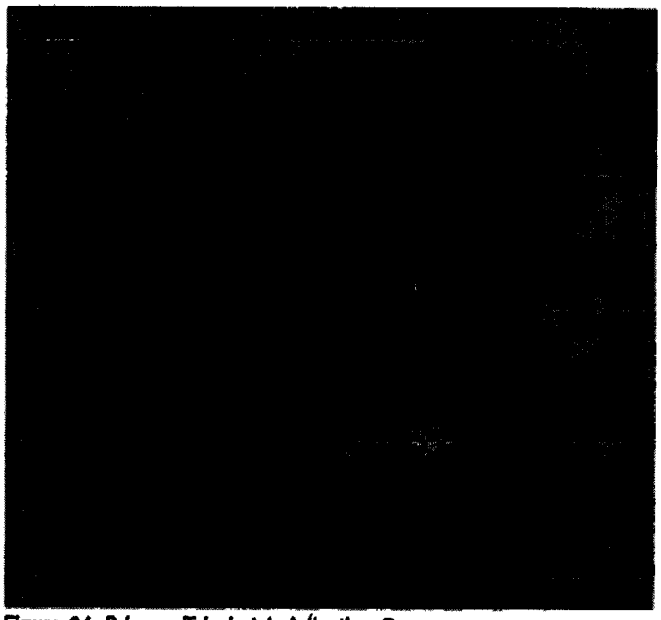


Figure 24. Primary Trip Latch Adjusting Screw

(5) Electrical Operation

After any necessary mechanical maintenance and lubrication are done, operate the circuit breaker electrically several times to ensure that the electrical control system works properly. See section headed "Electrical Operation" under the "Putting into Service" heading in this instruction book.

C. INTERRUPTER AND CONTACT AREA

(1) Vacuum Interrupter Contact Erosion

At each inspection, the vacuum interrupters should be checked for contact erosion. The breaker must be closed for this check. Each new vacuum interrupter is set with a gap of 0.250 inch between the lower contact block and the guide sleeve. As the contacts erode with use, this gap will decrease. When the gap reaches 0.125 inch the interrupter should be replaced. See Figure 25.

(2) Sliding Contact Finger Wear

Remove the four socket-head screws holding the sliding contact assemblies and pivot the assemblies down. Wipe the lubricant from the surfaces of the lower contact block, the

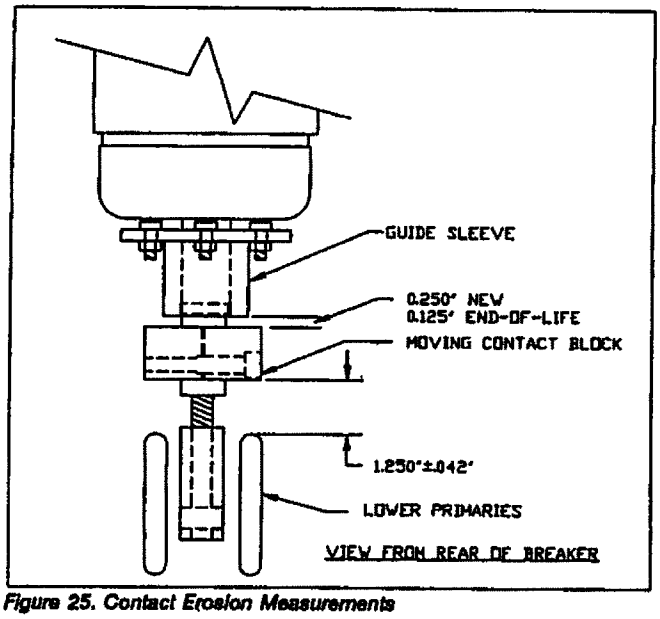


Figure 25. Contact Erosion Measurements

fingers and the lower main horizontal primary disconnect bars and examine these surfaces. The finger locations should present a burnished silver contact without copper appearance at more than one location. If copper is visible at more than one location per pole, or the silver is torn on the lower contact block, the interrupter should be replaced.

The sliding contact finger assemblies on the Powl-Vac circuit breaker are reversible. Since only the upper ends of the fingers experience any wiping action, the wear is normally confined to that end. If the upper ends of the fingers show noticeable wear, the finger assemblies should be reversed. Loosen the bolt holding the rear mounting clip and remove the finger assembly. Invert the assembly and replace it in the mounting clips, using the other tie rod to support the assembly. Tighten the bolt holding the rear mounting clip. If copper is visible at more than one contact location on a finger assembly, that assembly should be replaced.

Apply a light coat of Mobilgrease 28 contact lubricant to both sides of the contact blocks and to the contact areas of the lower main horizontal primary disconnect bars, then reassemble the sliding contact fingers.

(3) Mechanical Adjustment of Interrupters

There are several factory adjustments in the interrupter area which are described below. No adjustment of these settings is required for routine maintenance. The dimensions given below are for new interrupters, and all of them will change during the life of the interrupter. Adjustment of these settings will be required after interrupter replacement or any major overhaul of the breaker which involves interrupter or mechanism removal. **DO NOT ADJUST THESE SETTINGS UNNECESSARILY.**

a. With closed contacts on a new vacuum interrupter, the bottom of the moving contact block should be 1.250"±0.042" above the top of the lower main primary disconnect bars. See Figure 25.
b. With closed contacts on a new vacuum interrupter, the bottom of the pin which connects the bell cranks to the operating yoke should be [redacted] the bottom of the lower main primary [redacted]. See Figure 26.
c. With the breaker open, the dimension described in (b) should be 0.875"±0.015".
d. As explained in the description of the mechanism operation, when the breaker is closed a gap will exist between the contact loading spring yoke and the nut on the push rod stud, Figure 26. With a new vacuum interrupter, this gap will be between $^1/_2$ inch and $^5/_8$ inch. As the contacts erode, the gap will reduce to about $^1/_8$ inch.

If it is necessary to adjust any of these dimensions, refer to the procedures for replacing a vacuum interrupter in the **REPAIR PROCEDURES** section of this instruction book.

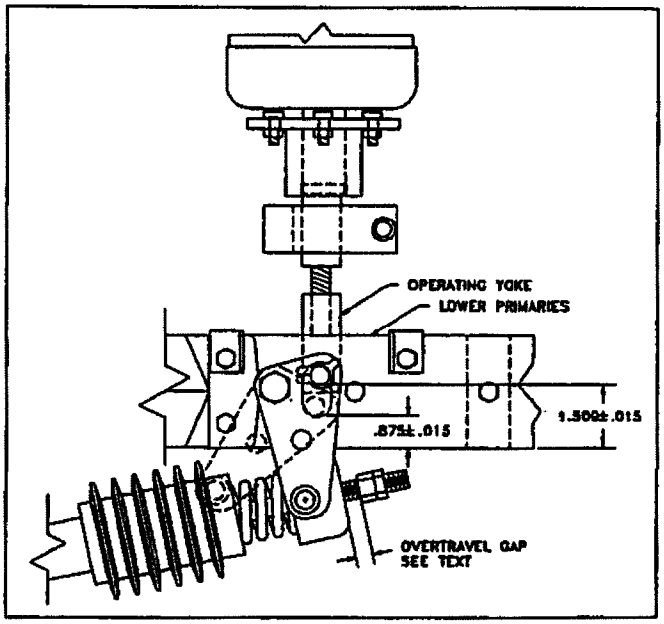


Figure 26. Operating Yoke Adjustments

(4) Vacuum Integrity

Refer to Page 10 for information on vacuum integrity and testing of interrupters.

D. OPTIONAL MAINTENANCE PROCEDURES

(1) High Potential Tests

These tests are not ordinarily required for routine maintenance, but should be performed after a heavy fault interruption or after the breaker has been in storage for an extended time, especially in a damp location or other adverse environment. Both the High Voltage Insulation Integrity and Control Voltage Insulation Integrity tests should be performed. See the section of this instruction bulletin headed "PUTTING INTO SERVICE" for details of these procedures.

(2) Primary Resistance Check

This check is not required for routine maintenance, but it is suggested after any major maintenance that requires disassembly of any part of the primary circuit, except for the sliding contacts. This check should be done after interrupter replacement.

To check the resistance, pass a minimum of 100A DC through the circuit breaker pole with the breaker closed. Measure the voltage drop across the primary contacts and calculate the resistance. This resistance should not exceed 55 micro-ohms for 1200A and 2000A breakers rated 15kV, 500 MVA Class, and it should not exceed 40 micro-ohms for any other circuit breaker.

When making this test, be sure that the test current passes through both main horizontal disconnect bars of each pair, or the resistance measurement will be affected. This may be done by connecting the current source leads to two blocks of full round edge copper 1 inch thick by 3 or 4 inches wide by 4 inches long, and pressing these blocks into the upper and lower disconnects of the circuit breaker. The blocks should be silver-or tin-plated to simulate the switchgear cell disconnects. The voltage drop measurement may be made between these two blocks.

VI. RECOMMENDED RENEWAL PARTS AND REPAIR PROCEDURES

A. ORDERING INSTRUCTIONS

(1) Order Renewal Parts from Powell Apparatus Service Division (PASD).

(2) Always specify complete nameplate information, including:

a. Type
b. Serial Number
c. Rated Voltage
d. Rated Amps
e. Impulse Withstand
f. Control Voltage (for control devices and coils)

(3) Specify the quantity and description of the part, and IB-60000. If the part is in the tables of recommended renewal parts, give its catalog number. If the part is not in the tables, the description should be accompanied by a marked illustration from this bulletin, a photo or a sketch showing the part needed.

(4) Standard hardware, such as screws, bolts, nuts, washers, etc., should be purchased locally. Hardware used in bolted joints of conductors must be SAE Grade 5 or better in order to insure proper clamping torque and prevent overheating of the joints. Hardware should be plated to deter corrosion.

B. RECOMMENDED RENEWAL PARTS

It is recommended that sufficient renewal parts be carried in stock to enable the prompt replacement of any worn, broken or damaged part. A stock of such parts minimizes service interruptions caused by breakdowns and saves time and expense. When continuous operation is a primary consideration, more renewal parts should be carried, the amount depending on the severity of the service and the time required to secure replacements.

Spare or replacement parts which are furnished may not be identical to the original parts, since improvements are made from time to time. The parts which are furnished, however, will be interchangeable. Tables II, III and IV list the recommended spare parts to be carried in stock by the user. The recommended quantity is not specified. This must be determined by the user based on the application. As a minimum, it is recommended that one set of parts be stocked per ten breakers or fraction thereof.

Table II. Interrupter and Sliding Contact Finger Assemblies

Breaker Type	Rated kV	Rated Continuous Current	Rated Momentary kA	Interrupter Assembly (3 per Bkr.)	Sliding Contact Finger Assembly (6 per Breaker)
5PV0250-3	4.76	1200A	58	60149-G1	50952-G1
5PV0250-3	4.76	2000A	58	60149-G1	50952-G1
15PV0500-3	15.0	1200A	37	60149-G2	50951-G1
15PV0500-3	15.0	2000A	37	60149-G2	50952-G1
15PV050H-3	15.0	1200A	58	60149-G2	50952-G1
15PV050H-3	15.0	2000A	58	60149-G2	50952-G1

Table III. Control Devices (1)

Control Voltage	Closing Coil	Shunt Trip Left(2)	Shunt Trip Right(3)	Under-voltage Device(4)	Charging Motor	Anti-Pump Relay
24VDC	N/A	50041-G5	50042-G6	50028-G4	N/A	N/A
48VDC	50026-G1	50041-G1	50042-G1	50028-G3	50960-G6	PVKUP11D55-48
125VDC	50026-G3	50041-G2	50042-G3	50028-G1	50960-G4	PVKUP11D55-110
250VDC	50026-G4	50041-G3	50042-G4	50028-G2	50960-G5	PVKUP11D55-110(5)
120VAC	50026-G1	50041-G1	50042-G1	N/A	50960-G4	PVKUP11A55-120
240VAC	50026-G2	50041-G6	50042-G2	N/A	50960-G5	PVKUP11A55-240
Capaci-tor Trip (6)	N/A	50041-G4	50042-G5	N/A	N/A	N/A

NOTES FOR TABLE III

1. One each required per breaker if breaker was originally equipped with this item. All breakers have closing coil, left shunt trip, charging motor, and anti-pump relay. Right shunt trip and undervoltage device are optional. See notes 2, 3 and 4.
2. Standard shunt trip.
3. Secondary shunt trip, where furnished. Cannot be present with undervoltage device.
4. Where furnished. Cannot be present with right-hand shunt trip.
5. For 250VDC applications, a dropping resistor, 50747-G2, is required in series with this relay's coil.
6. For use with capacitor trip units with 240VAC input. Consult factory for other ratings.

Table IV. Miscellaneous Parts

Qty/Bkr	Description	Catalog No.
18	Primary Contact Spring Assembly	50740-G1
1	Latch Check Switch	PVBA-2RV2-A2
1	Motor Cutoff Switch Assembly	50756-G1
	Ground Shoe Finger Assembly	
2	5PV0250-3, 1200A & 2000A	50952-G3
2	15PV0500-3, 1200A & 2000A	50951-G2
2	15PV050H-3, 1200A & 2000A	50952-G3
1	Auxiliary Switch Assembly	102108LH

C. REPLACEMENT PROCEDURES

This section includes instructions for replacing all the parts recommended as renewal parts. Before attempting any repair work, take note of safety practices outlined in Section II of this book.

MAKE CERTAIN THAT THE CONTROL CIRCUITS ARE DE-ENERGIZED AND THE BREAKER IS RESTING SECURELY OUTSIDE THE SWITCHGEAR HOUSING. DO NOT WORK ON A CLOSED BREAKER OR A BREAKER WITH THE CLOSING SPRINGS CHARGED.

(1) Vacuum Interrupter

a. Open circuit breaker and discharge closing spring.
b. Remove interphase barrier assembly.
c. Remove X-washer from one end of the vacuum interrupter operating pin, push down on the upper surface of the moving contact block to relieve any pressure on the pin, and pull the pin (d, Figure 9, Page 6). The X-washer can be opened by squeezing the two projecting tabs with pliers.
d. Remove the four socket-head screws, two on each side (f, Figure 9, Page 6), holding the sliding contact assemblies, and pivot the sliding contact assemblies down.
e. Unscrew and remove the operating yoke at the lower end of the vacuum interrupter (Figure 26).
f. Loosen, but do not remove, the two bolts through the upper contact block (k, Figure 9, Page 6).
g. Loosen, but do not remove, the four bolts connecting the vertical bars above the vacuum interrupter to the upper main horizontal primary disconnect bars.
h. While supporting the vacuum interrupter, remove the two bolts connecting the upper contact block to the vertical bars.
j. Remove the vacuum interrupter.
k. Unscrew the upper contact block from the vacuum interrupter.
l. Check the contents of the replacement vacuum interrupter kit. It should contain the following:
   1. A vacuum interrupter of the proper rating, with the lower contact block attached. Do not disturb the attachment of the contact block to the interrupter. This critical assembly has been made at the factory. Attempting to modify it may result in damage to the vacuum interrupter stem, making the interrupter unusable.
   2. Two X-washers.
   3. Two containers of lubricant, one tacky high pressure grease Anderol 757, and one contact grease Mobilgrease 28.
m. Screw the upper contact block onto the upper stem of the vacuum interrupter so that 3 to 5 threads of the interrupter stem protrude from the top of the contact block. This adjustment is not critical at this point, as it will be gauged later.
n. Install the new interrupter in the breaker by reversing steps j through e above.
p. Set the height of the interrupter in the breaker by rotating the interrupter. Be careful to turn the interrupter by its ceramic body. Do not attempt to turn it by the lower contact block or the movable stem, as this might result in damage to the interrupter's bellows and loss of vacuum. Rotate the interrupter until the lower surface of the lower contact block is 1.250" above the upper edge of the lower primaries. See Figure 25. Then rotate the interrupter as necessary to position the long edges of the block parallel to the lower primaries and the slot in the lower contact block at the rear of the breaker. Recheck the dimension between the lower surface of the contact block and the upper surface of the lower primaries. This dimension should be 1.250"±0.042".
q. Remove the nut from the bell crank mounting bolt and remove one bell crank.
r. Insert the pin through the operating yoke but not

through the bell cranks.

s. Set the height of the operating yoke so that the bottom of the pin is 1.500"±0.015" above the bottom edge of the lower primaries. See Figure 25.
t. Remove the pin and reassemble the bell crank.
u. Lubricate the pin with a liberal coat of the tacky high pressure grease, Anderol 757, insert the pin through both bell cranks and the operating yoke, and place a new X-washer in the groove of the pin. Press down on the upper surface of the contact block to aid in aligning the pin with the other parts. Tighten the X-washer by squeezing the two open ends together with pliers.
v. Tighten all bolts in the upper contact structure to 45 lb-feet.
w. Apply a light coat of Mobilgrease 28 contact lubricant to the left and right sides of the lower contact block and reassemble the sliding contact fingers.
x. With the circuit breaker open, check the dimension from the lower edge of the operating pin to the lower edge of the lower primaries. This dimension should be 0.875"±0.015". If this dimension is not correct, readjust the operating yoke until both the 1.500 inch and the 0.875 inch dimensions are within tolerance.
y. Close and open the circuit breaker about 50 times to properly seat the vacuum interrupter contact surface. Recheck all dimensions, and readjust as necessary.
z. Replace interphase barrier assembly.

(2) Sliding Contact Finger Assembly

Instructions are given in the maintenance section of this manual for removing and inverting the sliding contact finger assembly. Follow these instructions, but install the new finger assembly instead of re-installing the old one.

(3) Closing Coil Assembly

The closing coil is located in the lower front center of the circuit breaker. See Figure 3, Page 3. To replace it:

a. Remove front cover of the breaker.
b. Elevate the breaker so that there is at least 6 inches of clear space below the bottom pan of the breaker.
c. Unplug the closing coil from the wire harness.
d. Remove two bolts holding closing coil assembly to base pan and drop the closing coil out of the bottom of the breaker.
e. Insert new closing coil assembly into the breaker from below, bolt it in place and plug it into the wiring harness. No adjustment is required.
f. Close breaker several times electrically to insure that coil is functioning properly.
g. Replace front cover.

(4) Shunt Trip Coil Assembly, Left

This assembly is located in the center part of the mechanism area, just to the left of the main closing spring. See Figure 3, Page 3. To replace it:

a. Remove front cover of breaker.
b. Unplug the trip coil from the wiring harness.
c. Remove the two bolts holding the trip coil assembly to the breaker frame and remove the assembly.
d. Bolt new assembly in place and plug it into the wiring harness.
e. With the breaker mechanism in the reset position, check the gap between the trip coil armature and the trip lever extending from the trip shaft. This gap should be between 1/4 inch and 5/16 inch. If necessary, bend the trip lever slightly to achieve this setting. See Figure 27.
f. Trip the breaker electrically several times to insure that coil is functioning properly.
g. Replace front cover.

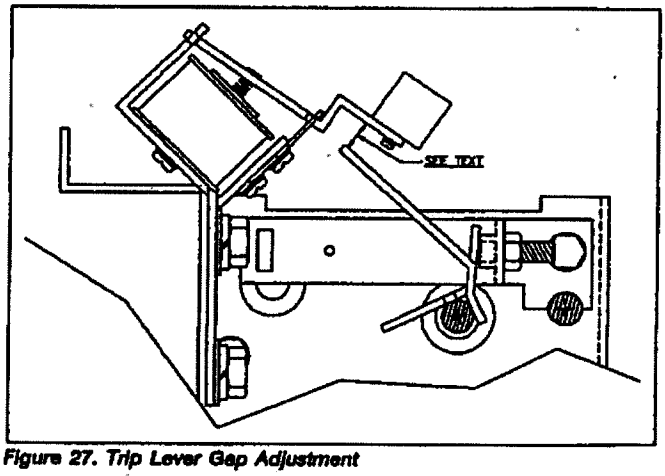


Figure 27. Trip Lever Gap Adjustment

(5) Shunt Trip Coil Assembly, Right

This assembly is located in the center part of the mechanism area, just to the right of the main closing spring. See Figure 12, Page 8. To replace it:

a. Remove front cover of breaker.
b. Unplug the trip coil from the wiring harness.
c. Remove the two bolts holding the trip coil assembly to the breaker frame and remove the assembly.

NOTE: It will be easier to remove the trip coil assembly if the right hand main operating spring connecting rod is removed. See section headed "Closing Spring Removal and Slow Closing of Mechanism" under Maintenance in this instruction book for procedures for removing this connecting rod.

d. Bolt new assembly in place and plug it into the wiring harness. No adjustment is required.
e. Re-assemble spring connecting rod and main spring, if previously removed.
f. Trip the breaker electrically several times to insure that the coil is functioning properly.
g. Replace front cover.

(6) Undervoltage Device Assembly

This assembly is located in the center part of the mechanism area, just to the right of the main closing spring. See Figure 28. To replace it:

a. Remove front cover of breaker.
b. Remove right hand main operating spring connecting rod. See section headed "Closing Spring Removal and Slow Closing of Mechanism" under Maintenance in this instruction book for procedures for removing this rod.
c. Unplug the undervoltage device from the wiring harness.
Remove the two bolts holding the undervoltage device assembly to the breaker frame and remove the assembly.

Figure 28. Undervoltage Device Mounted on Circuit Breaker

e. Bolt new assembly in place.
f. Re-assemble the main operating spring connecting rod.
g. While the undervoltage device has been tested at the factory, it is necessary to check and possibly adjust its settings once it has been assembled to the circuit breaker. This will require a variable voltage DC source capable of output of from 40% to 100% of the DC rating of the undervoltage device. Connect this source to the terminals of the undervoltage device coil.
Apply a DC voltage of 80% of the undervoltage coil rating. The undervoltage device should pick up and allow the breaker to close. Close and trip the breaker several times, using manual or shunt trip, to be sure that the vibration of breaker operation does not cause the undervoltage device to drop out improperly. If the device does drop out during this test, rotate the knob at the bottom of the device to the right in 1/8 turn steps until the proper operation is obtained. This adjustment may be fine turned by bending the tab at the base of the beam spring up in 1/16 inch steps. See Figure 29.
Check dropout of undervoltage device by reducing test voltage to 52-56%. The undervoltage device should drop out and cause the breaker to trip in this voltage range. If dropout voltage is too low, bend the tab at the base of the beam spring down slightly to raise the voltage.

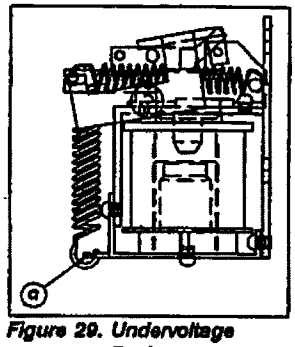


Figure 29. Undervoltage Device
a. Beam Spring Tab

h. Disconnect the test source and plug the undervoltage device into the wiring harness.
i. Replace front cover.

(7) Charging Motor Assembly

The charging motor assembly is located at the lower right-hand side of the mechanism (See Figure 4, Page 3). To replace it:

a. Remove front cover of the breaker.
b. Unplug the motor from the wiring harness.
c. Remove the two bolts holding the motor mounting bracket to the base pan and slide the motor to the right, disconnecting the motor shaft from the mechanism, and lift the motor out.
d. Lubricate the end of the shaft of the new motor liberally with Anderol 757 grease.
e. Position the new motor assembly in the circuit breaker, being sure that the pin on the end of the drive shaft engages the slot in the mechanism shaft.
f. Bolt the motor to the base pan and plug it into the wiring harness.
g. Operate the circuit breaker several times to insure that the motor operates smoothly.
h. Replace front cover.

(8) Anti-Pump Relay

This relay is located near the top of the mechanism, to the left of the main operating springs. See Figure 30. To replace it:

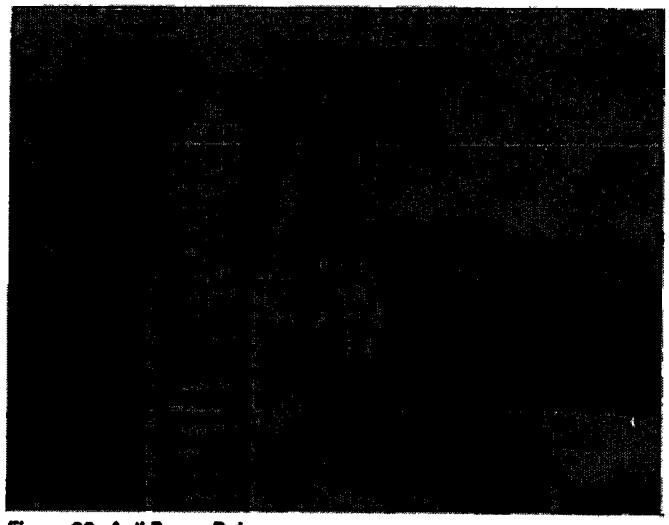


Figure 30. Anti-Pump Relay

a. Remove front cover of breaker.
b. Disconnect leads from anti-pump relay, being careful to note which wires go to which terminal.
c. Loosen lower mounting screw of relay.
d. Remove upper mounting screw and lift relay off lower screw.
e. Place new relay over lower screw, reinstall upper screw, and tighten both screws.
f. Reconnect all wires to the proper terminals of the relay.
g. Relays in 250VDC closing circuits are provided with dropping resistors to apply the proper voltage to the relay coil. The resistor is mounted adjacent to the relay. It may be replaced by unplugging it from the relay and unscrewing the mounting feet from the breaker frame, replacing the resistor and reassembling.
h. Operate the breaker several times to insure that the relay functions properly.
i. Replace front cover.

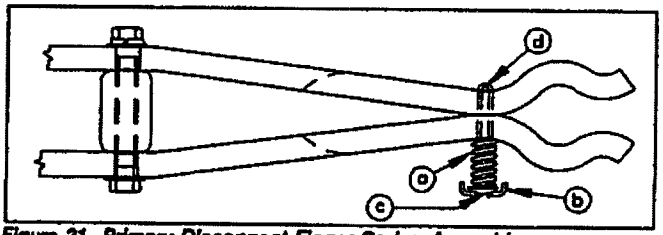


Figure 31. Primary Disconnect Finger Spring Assembly

a. Spring
b. Support
c. Cap
d. Keeper

(9) Primary Contact Spring Assembly

These springs are located at the outer end of the primary contact bars. See Figure 31. To replace them:

a. Depress spring support sufficiently to allow keeper to be removed.
b. Remove cap, spring support and spring.
c. Slide new spring onto spring support and place spring support in slot between fingers.
d. Depress head of spring support and install keeper in slot in end of spring support.
e. Release spring slowly, allowing keeper to seat properly.

NOTE: Springs are to be installed in every other slot in fingers; top, center and bottom. The second and fourth slots are empty.

(10) Latch Check Switch

The latch check switch is located on the left-hand side of the main mechanism frame, near the bottom of the main closing spring. See Figure 5, Page 4. To replace it:

a. Remove the front cover of breaker.
b. Remove two screws holding switch to mechanism. Do not lose nut plate into which these screws are threaded.
c. Disconnect wires from switch.
d. Connect wires to new switch and fasten switch in place with screws and nut plate previously removed.
e. Adjust switch per instructions in section headed "Adjustment of Primary and Secondary Trip Latches and Latch Check Switch" under MAINTENANCE in this instruction book.
f. Operate breaker electrically several times to insure that it is working.
g. Replace front cover.

(11) Motor Cutoff Switch Assembly

The motor cutoff switch assembly is located on the floor pan of the mechanism area, just to the right of the main mechanism. See Figure 4, Page 3. To replace it:

a. Remove the front cover of breaker.
b. Disconnect wires from switch, being careful to identify each wire by the terminal number from which it was removed.
c. Remove the two bolts holding the assembly to the breaker floor pan and remove the assembly.
d. Install new cutoff switch assembly, bolt it to the floor pan. Reconnect the wiring. No adjustment is needed.
e. Operate breaker electrically several times to insure that it is working.
f. Replace front cover.

(12) Ground Shoe Finger Assembly

The ground shoe assembly is located at the rear edge of the breaker floor pan between the center and right poles of the breaker. See Figure 32. To replace it:

a. Elevate the breaker so that there is at least 6 inches of clear space below the bottom pan of the breaker.
b. Remove bolts holding two ground shoe mounting brackets to ground bar, and remove the two brackets.
c. Press down on finger assembly and remove it from bottom of breaker.
d. Remove from socket-head screws holding two side finger assemblies to two red spacer tubes.
e. Assemble new side finger assemblies to red spacer tubes.
f. Wipe old lubricant off ground bars on breaker and apply a thin coat of contact lubricant Mobilgrease 28 to ground bars.
g. Insert new finger assembly from below the breaker floor pan and press up until the upper lobe of the fingers snaps into place on the ground bus.
h. Reinstall the two mounting brackets.

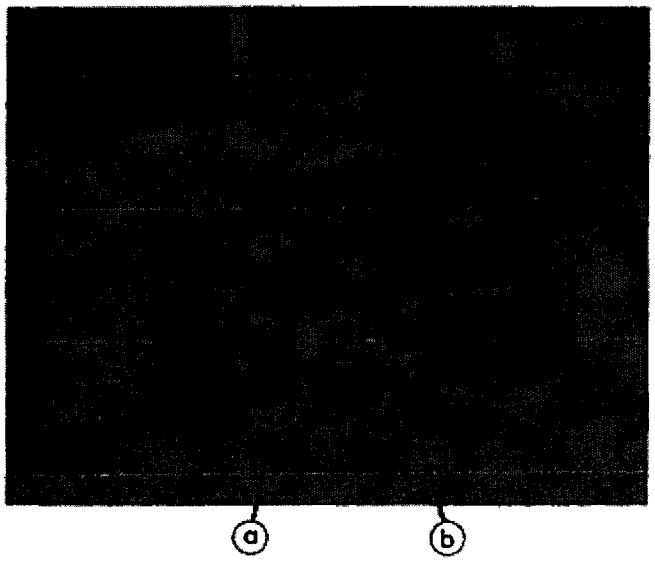


Figure 32. Ground Shoe

a. Mounting Brackets
b. Holding Bolts

(13) Auxiliary Switch

The auxiliary switch is located in the lower left front of the mechanism area. See Figure 33. To replace an auxiliary switch:

a. Remove the front cover of breaker.
b. Disconnect wires from switch, being careful to identify each wire by the terminal number from which it was removed.
c. Remove the "E" ring securing the switch operating arm to the operations counter linkage.
d. Remove the two screws holding the auxiliary switch to its mounting bracket, and remove the switch.
e. Insert the new switch and attach it to the mounting bracket with the two screws removed in step d.
f. Insert the operating arm of the switch into the hole in the end of the operations counter linkage and secure with the "E" ring removed in step c.
g. Reconnect the wiring. Be sure wires are connected to the same terminals from which they were removed.
h. Operate breaker electrically several times to insure that it is working.
i. Replace front cover.

Figure 33. Auxiliary Switch

How to use this Site

TO CONFIGURE: Select Base, Options, Poles & Handles. Click Configure. Needs to start with Style Number.

TO SEARCH: Want to view an existing Code No. or Style No.

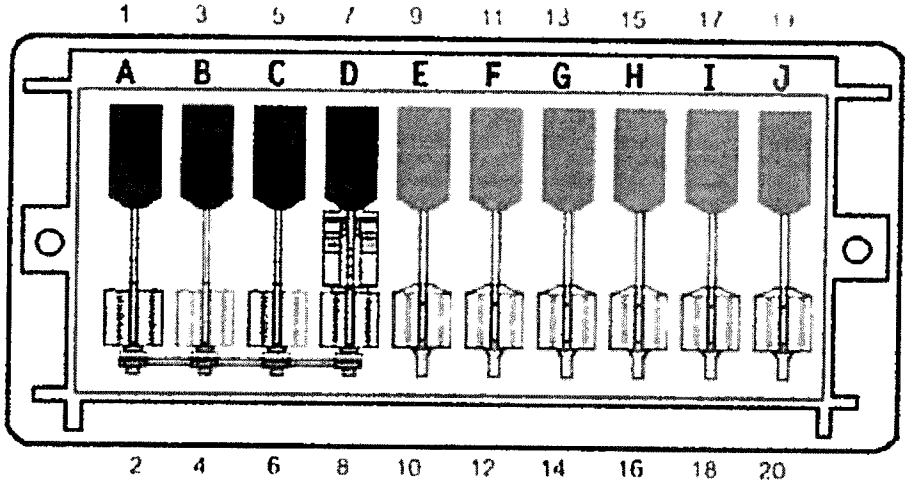
Select Base: Stand Alone FT-1 | FT-19R Replacement FT-1 | Front Connected FT-1F | FT-1J

Select Options:

Cover:
- * Black Cover
- Clear Cover

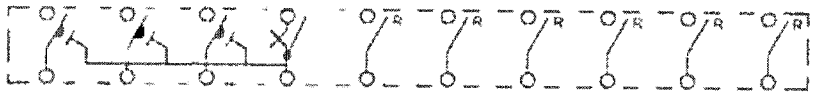
Terminals:
- * Screw Terminals
- Stud Terminals

Depth:
- * Standard
- Extended [1]



	All	A	B	C	D	E	F	G	H	I	J
Select Poles	▼	C ▼	C ▼	C ▼	C ▼	P ▼	P ▼	P ▼	P ▼	P ▼	P ▼
Select Handles	▼	Blk ▼	Blk ▼	Blk ▼	Blk ▼	Red ▼	Red ▼	Red ▼	Red ▼	Red ▼	Red ▼

Configure / Reset



FT-1 Stand Alone	Style No	9672A99G01	Code No	442
	Arrangement	C C C C T T T T T T	No of Poles	10
		C1 C1 C1 C1 P2 P2 P2 P2 P2 P2	No of Terminals	6
Data Sheet	Options	Black Cover Screw Terminals	No of Currents	4