GUAM POWER AUTHORITY
ATURIDÅT ILEKTRESEDÅT GUÅHAN
P.O.BOX 2977 • HAGÅTÑA, GUAM U.S.A. 96932-2977

December 19, 2025

AMENDMENT NO.: IV

TO

INVITATION FOR BID NO.: GPA-003-26

FOR

ON-SITE MAINTENANCE AND REPAIR OF THE MACHECHE SUBSTATION'S T90 POWER TRANSFORMERS ON-LOAD TAP CHANGER (OLTC)

Prospective Bidders are hereby notified of the following inclusion and response to inquiries received from Bidder No. 7 dated November 7, 2025, Bidder No. 8 dated November 5, 2025:

INCLUSION:

Attachment A – Instruction Manual for the transformer and the On-Load Tap Changer (OLTC) mechanism of the transformer

RESPONSE:

Bidder No. 7 dated 11/07/2025:

QUESTION:

1. We would like to request a copy of the following for the OLTC:
   1. Control Diagram
   2. Operation Manual

   We would also request that the bid opening date be extended for another 2 weeks to enable us enough time to source out the necessary parts and supplies needed for this project.

ANSWER:

Refer to *INCLUSION* above (Attachment A).

Refer to Amendment No.: III issued December 12, 2025.

Bidder No. 8 dated 11/05/2025:

QUESTION:

1. Due to the time and coordination with Equipment Manufacturers, may we request time extension to submit bid instead by November 21, 2025, same time.

Also, we find the Required Completion of Eight (8) weeks upon NTP, may not be enough if extent of repair will need replacement of parts still to be manufactured. The Transformer and OLTC is almost 35 years in-service. Time extension will depend on the extent of damage. May our request time extension be considered.

ANSWER:

Refer to Amendment No.: III issued December 12, 2025.

GPA stands firm on the Completion Time of 8 Weeks Upon Issuance of Notice to Proceed (NTP). However, based on findings of the awarded vendor, and during the project and sourcing of required parts an extension may be considered.

All other Terms and Conditions in the bid package shall remain unchanged and in full force.

JOHN M. BENAVENTE, P.E.
General Manager

ATTACHMENT A

Instruction Manual for the transformer and the On-Load Tap Changer (OLTC) mechanism of the transformer

NO. TE-772311-A

CUSTOMER: GUAM POWER AUTHORITY(GPA)

OBJECTS : POWER TRANSFORMER

TYPE FORM : HC/OP/OPTLR

No. OF PHASE : THREE

FREQUENCY : 60 Hz

CAPACITY : 15/20/25/28 MVA

PRIMARY VOLTAGE : 36220/35360/34500/33640/32780 V

SECONDARY VOLTAGE:

13800±10%(33TAPS) V

MFG. DATE : MAR.,1989

SER. No. :

2.11 DEHYDRATING BREATHER(FOR MAIN BODY AND O.L.T.C.) ---HIE-0126-79

2.12 TYPE OH-D OIL-PRESERVATION SYSTEM ----------HIE-0129-81

2.13 OIL SAMPLING PLUG ----------HIE-0135-87

2.14 COOLING FANS ----------HIE-0222-86

2.15 DIAL THERMOMETER(FOR OIL TEMP.) ----------HIE-0229-82

2.16 DIAL THERMOMETER(FOR WINDING TEMP.) ----------HIE-0230-84

2.17 SUDDEN OIL PRESSURE RELAY ----------HIE-0233-86

2.18 BUCHHOLZ RELAY ----------HIE-0238-87

2.19 HANDLE OPERATING MECHANISM(FOR OFF-LOAD) ----------HIE-0319-85

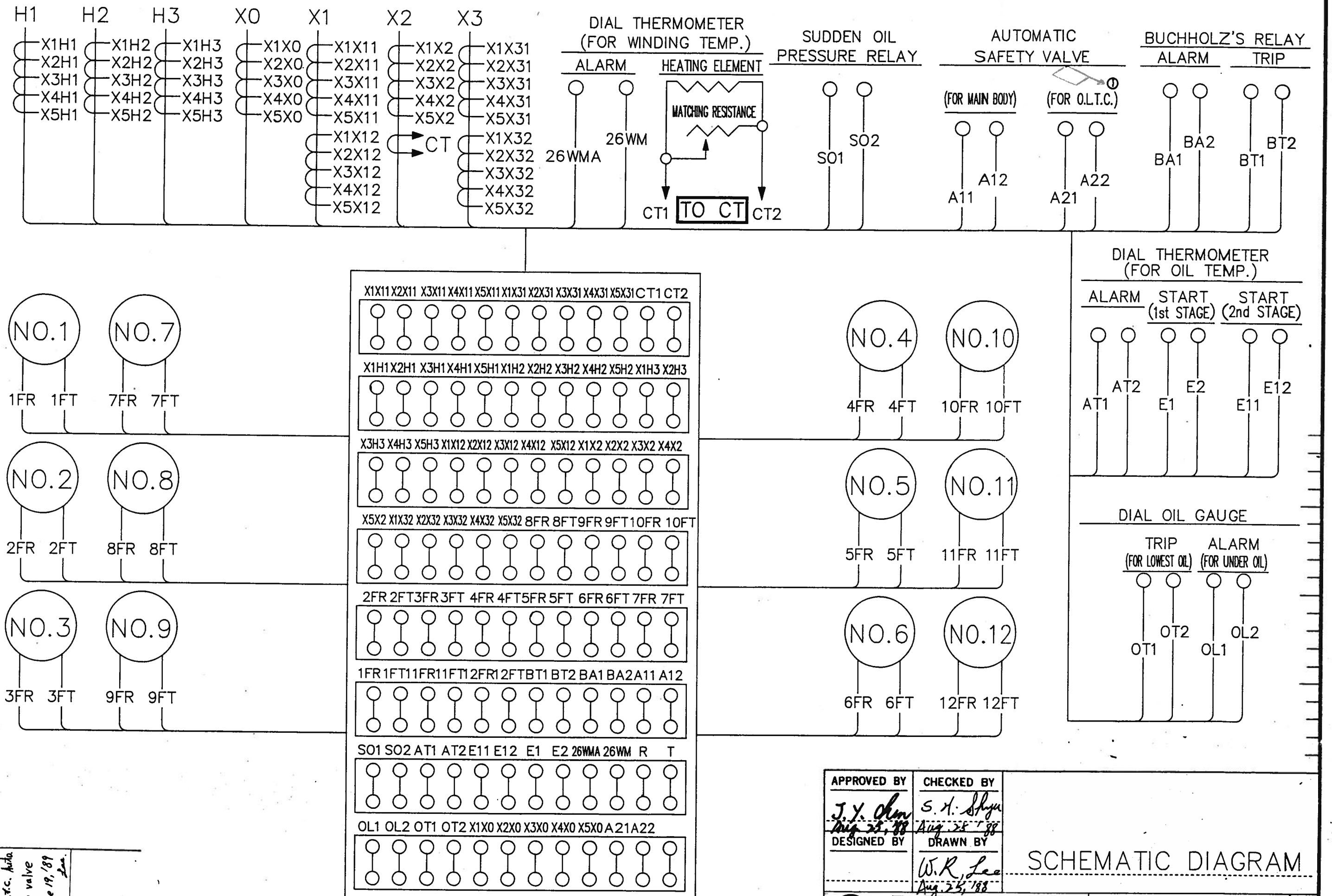
①2.20 G.P.A. 15/20/25 MVA DATA----------R-3974-1

END.

APPROVED BY	CHECKED BY	DRAWEN BY	①Adding #2.20. June 22, '89 Lee
R.S. Jiang	J.Y. Chen	W.R. Lee	
Mar. 11, 89	Mar. 11 '89	Mar. 11, 89	

HEAVY ELECTRIC APPARATUS FACTORY

TATUNG CO.



① Adding connective point of o.l.t.c. huts safety valve June 19, '89 Lee.

APPROVED BY	CHECKED BY
J.Y. Chen Aug 25, '88	S.H. Shyu Aug 25 '88
DESIGNED BY	DRAWN BY
	W.R. Lee Aug. 25, '88

SCHEMATIC DIAGRAM

TATUNG CO.
TAIPEI THE REPUBLIC OF CHINA

453-07348 ①

REGISTERED

1 2 3 4 5 6 7 8 9

A B C D E F

* ABOUT THE LTC ON AUTO. WE HAVE OTHER INSTRUCTION BOOK ATTACH FOR YOU.

SUPPLY PARTS ONLY FURNISH BY G.P.A.

"REMOTE CONTROL ROOM"

AUTO MANU RAISE LOWER

SOURCE T S R

TR 3ϕ 34.5KV/13.8KV 28MVA

BCT 2000/5A C10 C20

PT 3ϕ Y-Y 8400/120V V10 V20

LOAD N T S R

C.T.T C11 C12

AUX-CT 5/0.2A

P.T.T V11 V12 V21 V22

F 2A V/3

V Scale 0~15KV

"90" 90X 27X R213 R214 R215 R216 R217 R218 R219 R220 R221 R222 45TX 90R 90L

LOCAL REMOTE R211 R223

AUTO MANU

RAISE RAISE

R224 R225

T211 T212 T213 T214

O G R W 48T

RESET P.B R227 R226 48TX

TPI

R210 T210 R212 R223 R215 R216

FROM SH-03 R21T21

T210

"LOCAL CONTROL CUBICLE"

FROM SH-05 R32 T31

Q1 (31) K1 K2 K4 K5 K7 K8 K11 K1K D1 M1 M 3~

S40 S11 (39) S12 (28) S1 S2 S35 S36 S8 S9 (57) S23 NL NR S37 S11 (23)

SEQUENCE DIAGRAM /STEP

S37 S36 S35 S12 S11

8 REVOLUTIONS OF TAKE-OFF SHAFT/STEP

S37 S16 S33

R1 0~200 Ohm

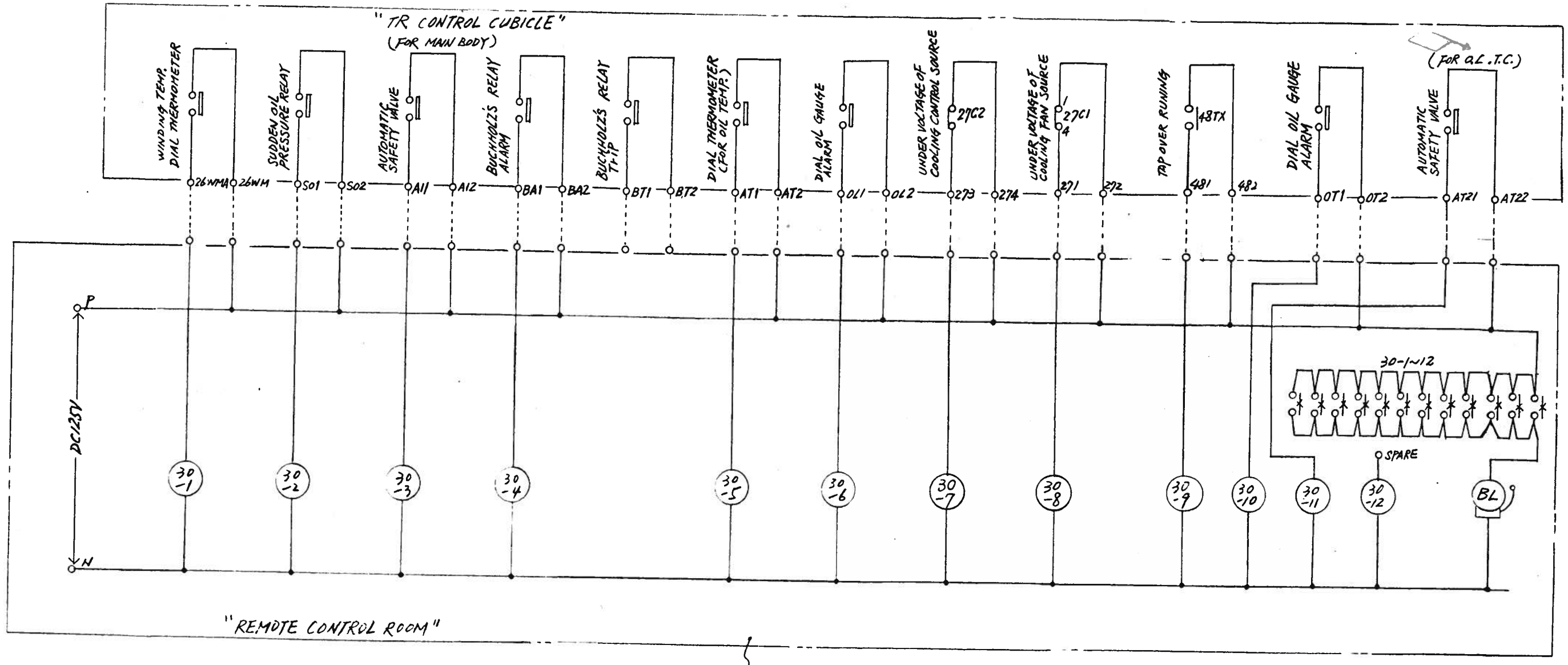
E1

C1	STARTING CATACITOR 18uF	R5	DAMPING RESISTOR 4 OHMS
C2	OPERATING CAPACITOR 30uF	S1-2	KEY FOR STEP BY STEP CONTROL
D1	IMPULS COUNTER	S3-4	KEY FOR STEP BY STEP CONTROL
E1	HEATING ELEMENT	S6	KEY FOR EMERGENCY STOP
H1	PROGRESS LAMP	S8-9	LIMIT SWITCH
K1-2	MOTOR CONTACTOR	S11-12	DIRECTION OF ROTATION SWITCH
K4	BRAKING CONTRCTOR	S16	MULTI-CONTACT DIAL SWITCH
K5	STEP BY STEP CONTACTOR	S35-36	CONTROL CONTACT
K7-8	AUXILIARY RELAY	S37	AUXILIARY CONTACT
K11	TIME DELAY RELAY	S40	SECURITY SWITCH
M1	DRIVING MOTOR	X10	TERMINAL STRIP
Q1	MOTOR PROTECTIVE SWITCH		
R1	RESISTANCE TELE-TARNSMITTER		

NO.1
MOTOR DRIVE MA-E/4(TU)

REVISION	
1	Revise Dec.-7-'88 Aviction
2	Revise JUNE-20-'89 Aviction

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY	G.P.A 28MVA MOTOR DRIVE CONTROL CIRCUIT
C.H Lee		Aviction-Tsai	J-U-Wu	
DEC-2-'88		OCT-14-'88	77-10-08	

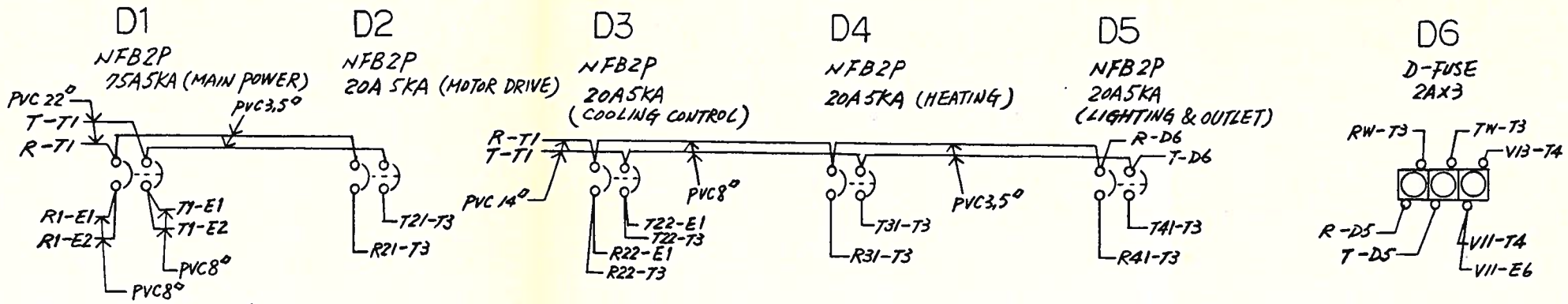


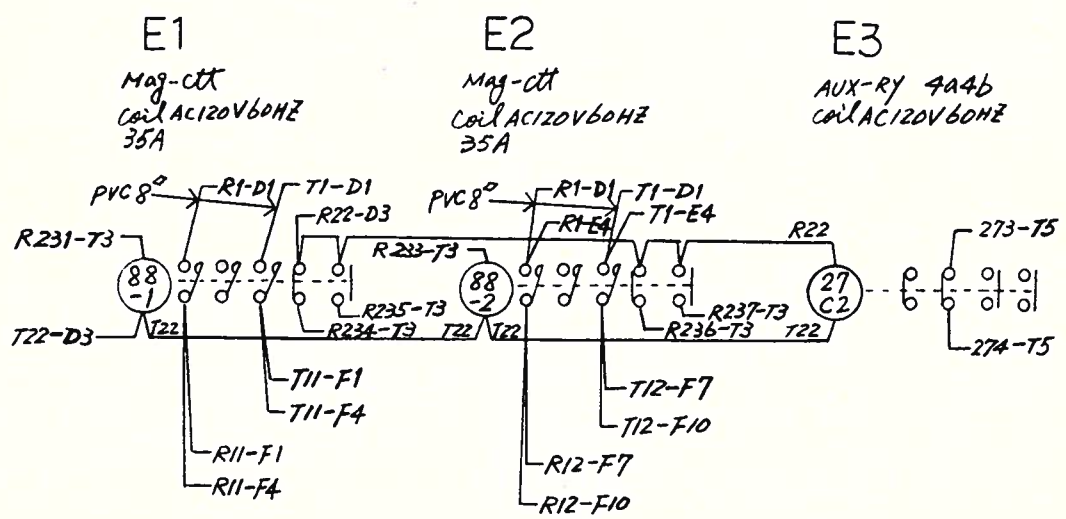
SUPPLY PARTS ONLY FURNISH BY G.P.A.

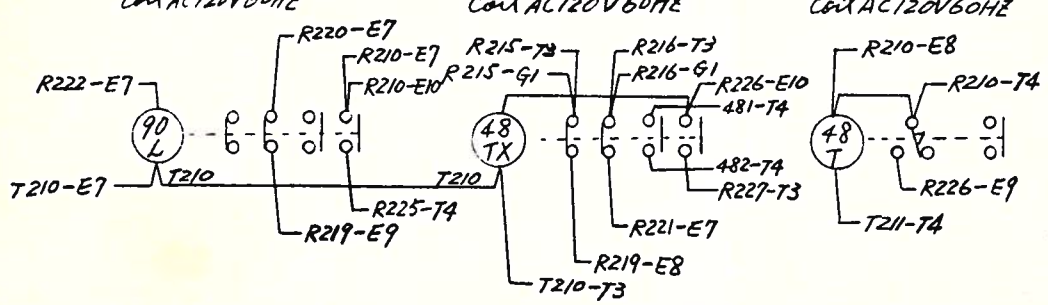
REVISION		
1	Revise Dec.-8-'88 Avictor	
2	Revise JUNE-20-'89 Avictor	

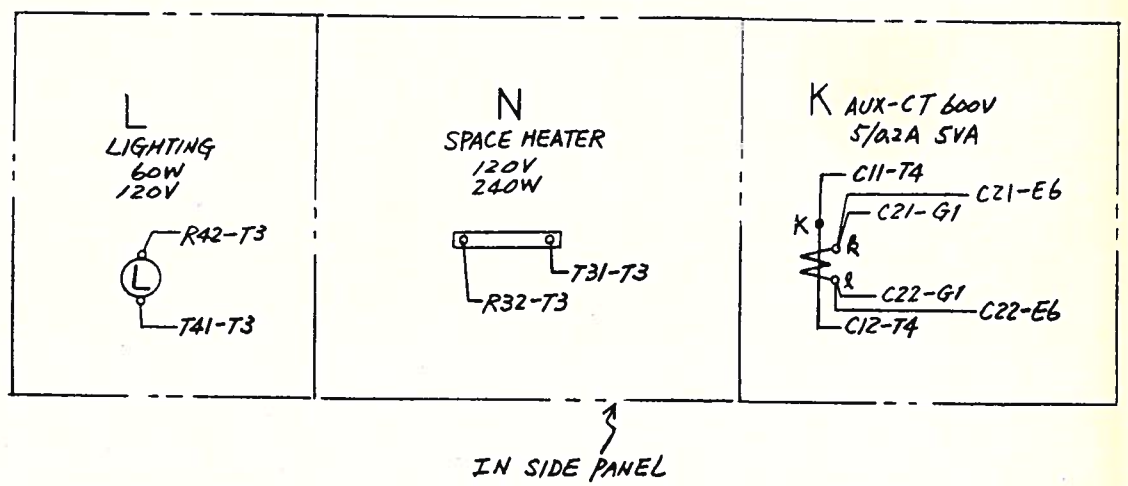
APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY	G.P.A 28MVA ALARM CIRCUIT
E. S. Yeh		AVICTOR-Tsai		
Nov 1 -'88	— —	Oct 14 -'88	— —	478-02165~07
REGISTERED				

G.P.A. P.O. NO. B800-01137









REVISION		
1	Revise JUNE-20-'89 Avicton	

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY	CONNECTION DIAGRAM "B"
C.H CHU		Avicton-Tsai		
MAY 17-'89	— —	MAY 2-'89	— —	478-02165~09
REGISTERED				

GPA. PO. NO B800-01137

F1 NFB2P 10A 5KA
F2 〃
F3 〃
F4 〃
F5 〃
F6 〃
F7 〃
F8 〃
F9 〃
F10 〃
F11 〃
F12 〃

R11-E1
T11-E1
1FT-T1
1FR-T1
2FT-T1
2FR-T1
3FT-T1
3FR-T1
R11-E1
T11-E1
4FT-T1
4FR-T1
5FT-T1
5FR-T1
6FT-T1
6FR-T1
R12-E2
T12-E2
7FT-T2
7FR-T2
8FT-T2
8FR-T2
9FT-T2
9FR-T2
R12-E2
T12-E2
10FT-T2
10FR-T2
11FT-T2
11FR-T2
12FT-T2
12FR-T2

G2
THERMOSTAT
0~40°C
R31-T3
R32-T3

G1 AVR 95~130V
0.2A
"90"
MK20
1 2 11 12 10 9 8 7 6 5 20 19 13 14 15 16 17 18 22 23 21
V12-E6
V22-E6
C22-K
C21-K
R213-E6
R215-E9
R216-E9
R210-E7
R217-E5

T3
TB30P30AX1
R21-D2
T21-D2
R22-C2
T22-B2
R31-D4
R32-G2
T31-D4
R41-H1
R42-H1
T41-D5
RW-A1
RW-D6
TW-A1
TW-D6
R210-T4
R210-B7
R212-E6
R212-C4
R215-E9
R215-C3
R216-E9
R216-C3
R223-B7
R227-B3
R231-C2
R233-C1
R234-B2
R235-B2
R236-B1
R237-B1
T210-T4
T210-E9
T211-T4
T211-B5
T212-T4
T212-B6
T213-B4
T213-T4
R21
T21
R22
T22
R31
R32
T31
R41
R42
T41
RW
TW
R210
R212
R215
R216
R223
R227
R231
R233
R234
R235
R236
R237
T210
T211
T212
T213
R22-T5
R22-D3
T22-D3
R31-G2
R32-N
T31-N
R41-D5
R41-J
R42-L
T41-J
T41-L
R227-E9
R231-E1
R233-E2
R234-E1
R235-E1
R236-E2
R237-E2
TO CONTROL ROOM
TO CONTROL ROOM

T4
TB12P30AX2
C10-H2
C11-H2
C12-H2
C20-H2
V10-H3
V11-H3
V11-D6
V13-D6
V20-H3
V21-H3
T214-A2
R210-E10
R210-T3
T210-T3
R225-E8
R224-E7
T211-E10
T211-T3
T212-T3
T213-T3
481-E9
482-E9
C10
C11
C12
C20
V10
V11
V13
V20
V21
12
13
16
26
27
28
29
31
32
35
36
37
481
482
E
C10-T7
C11-K
C12-K
C20-T7
V13-A3
V21-E6
PVC5.5°
G.B. 3.5x25

T5
TB12P30AX2
26WMA
26WMB
S01
S02
A11
A12
BA1
BA2
BT1
BT2
AT1
AT2
0L1
0L2
0T1
0T2
E1
E2
E11
E12
271
272
273
274
R22-T3
R230-C2
R232-C1
271-E4
272-E4
273-E3
274-E3

T6 12P30AX2
CT TB/WITH SHORT BAR
X1H1
X2H1
X3H1
X4H1
X5H1
X1H2
X2H2
X3H2
X4H2
X5H2
X1H3
X2H3
X3H3
X4H3
X5H3
X1X0
X2X0
X3X0
X4X0
X5X0
X1X11
X2X11
X3X11
X4X11

T7 〃
C10-T4
C20-T4
X1X12
X2X12
X3X12
X4X12
X5X12
X1X2
X2X2
X3X2
X4X2
X5X2
CT1
CT2
X1X31
X2X31
X3X31
X4X31
X5X31
X1X32
X2X32
X3X32
X4X32
X5X32
X5X11

J
OUTLET
AC250V
10A
T41-T3
R41-T3
TB 3P30AX1
A21
A22

T1
TB12P30AX1
3P150AX1
1FR
1FT
2FR
2FT
3FR
3FT
4FR
4FT
5FR
5FT
6FR
6FT
1FR-F1
1FT-F1
2FR-F2
2FT-F2
3FR-F3
3FT-F3
4FR-F4
4FT-F4
5FR-F5
5FT-F5
6FR-F6
6FT-F6

T2
TB12P30A
7FR
7FT
8FR
8FT
9FR
9FT
10FR
10FT
11FR
11FT
12FR
12FT
7FR-F7
7FT-F7
8FR-F8
8FT-F8
9FR-F9
9FT-F9
10FR-F10
10FT-F10
11FR-F11
11FT-F11
12FR-F12
12FT-F12

R-D3
R-D1
T-D3
T-D1
R
T
PVC14°
PVC22°

※ ALL WIRE ARE USE PVC3.5° EXCEPT LABEL ON ARROW.

REVISION	
1	REVISE JUNE-20-'89 Avicter

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY	
C.H LEE		Avicter-Tsai		CONNECTION DIAGRAM "C"
Mar-13-'89	— —	Mar-2-'89	— —	478-02165~10
REGISTERED				

G.P.A. P.O. NO. B800-01137

GPA 15/20/25 MVA DATA

No. R-3974-1

PAGE 1E

1. CUSTOMER: GUAM POWER AUTHORITY (GPA)

2. TRANSFORMER RATING: 15/20/25 MVA, 345KV – 13.8KV

3. CAPACITY BY No. OF COOLING FANS OPERATED.

ITEM	NUMBER OF COOLING FANS	CAPACITY (MVA)*
1	12	25
2	10	23.5
3	8	22
4	6	20
5	4	18.75
6	2	17.5
7	0	15

* THIS FIGURE IS DESIGN VALUE.

APPROVED BY	CHECKED BY	DRAWN BY
	C.T. JUANG JUN. 21st, '89	Y. L. Chen JUN. 21, 1989

HEAVY ELECTRIC APPARATUS PLANT

U TRANSFORMER

NO. TE-772311-A

CUSTOMER: GUAM POWER AUTHORITY(GPA)

OBJECTS : POWER TRANSFORMER

TYPE FORM : HC/OP/OPTLR

No. OF PHASE : THREE

FREQUENCY : 60 Hz

CAPACITY : 15/20/25/28 MVA

PRIMARY VOLTAGE : 36220/35360/34500/33640/32780 V

SECONDARY VOLTAGE:

13800±10%(33TAPS) V

MFG. DATE : MAR.,1989

SER. No. :

TATUNG TAIWAN THE REPUBLIC OF CHINA

1.DRAWING:

1.1 OUTLINE OF POWER TRANSFORMER ----------452-08915

1.2 NAMEPLATE OF POWER TRANSFORMER ----------451-01395

1.3 OUTLINE OF H.V. BUSHING ----------454-79280

1.4 OUTLINE OF H.V. TERMINAL ----------454-53754

1.5 OUTLINE OF L.V. BUSHING ----------454-79239

1.6 OUTLINE OF L.V. NEUTRAL BUSHING ----------454-79119

1.7 OUTLINE OF COOLING FAN ----------454-79282

1.8 GROUNDING PAD ----------454-76325

1.9 SURGE ARRESTER ----------454-33415

1.10 LIST OF ALL SPECIAL TOOLS ----------454-45377

1.11 LIST OF RECOMMENDED SPARE PARTS ----------Q8-25601-1

1.12 SCHEMATIC AND WIRING DIAGRAM ----------453-07348

1.13 CONTROL ELEMENTARY AND LTC CONTROL ELEMENTARY AND WRING DIAGRAM(INTERCONNECTION WIRING DIAGRAM)------478-02165

2.INSTRUCTION:

2.1 SOLID-STATE VOLTAGE REGULATOR(MK20) ----------HR-64020-43-1

2.2 ON-LOAD TAP-CHANGERS FOR TRANSFORMER ----------HR-64016-60-1

2.3 MOTOR DRIVE UNIT ----------HR-64016-92

2.4 MAINTENANCE OF POWER TRANSFORMER ----------HIE-0039-82

2.5 IMPORTANT POINTS OF INSTALLATION ----------HIE-0021-82

2.6 LONG-TERM STORAGE FOR TRANSFORMER OR REACTOR --------HIE-0043-84

2.7 TOP FILTER VALVE ----------HIE-0107-87

2.8 PRESSURE RELIEF DEVICE ----------HIE-0113-82

2.9 OIL GAUGE(FOR MAIN BODY) ----------HIE-0122-87

2.10 OIL GAUGE(FOR O.L.T.C---NO ALARM) ----------HIE-0123-88

CONTINUE-----

APPROVED BY	CHECKED BY	DRAWEN BY		HEAVY ELECTRIC
R.S. Jiang	J.Y. Chen	W.R. Lee		APPARATUS FACTORY
Mar. 11, 89	Mar. 11 89	Mar. 11, '89		

TATUNG CO.

2.11 DEHYDRATING BREATHER(FOR MAIN BODY AND O.L.T.C.) ---HIE-0126-79

2.12 TYPE OH-D OIL-PRESERVATION SYSTEM ----------HIE-0129-81

2.13 OIL SAMPLING PLUG ----------HIE-0135-87

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2.15 DIAL THERMOMETER(FOR OIL TEMP.) ----------HIE-0229-82

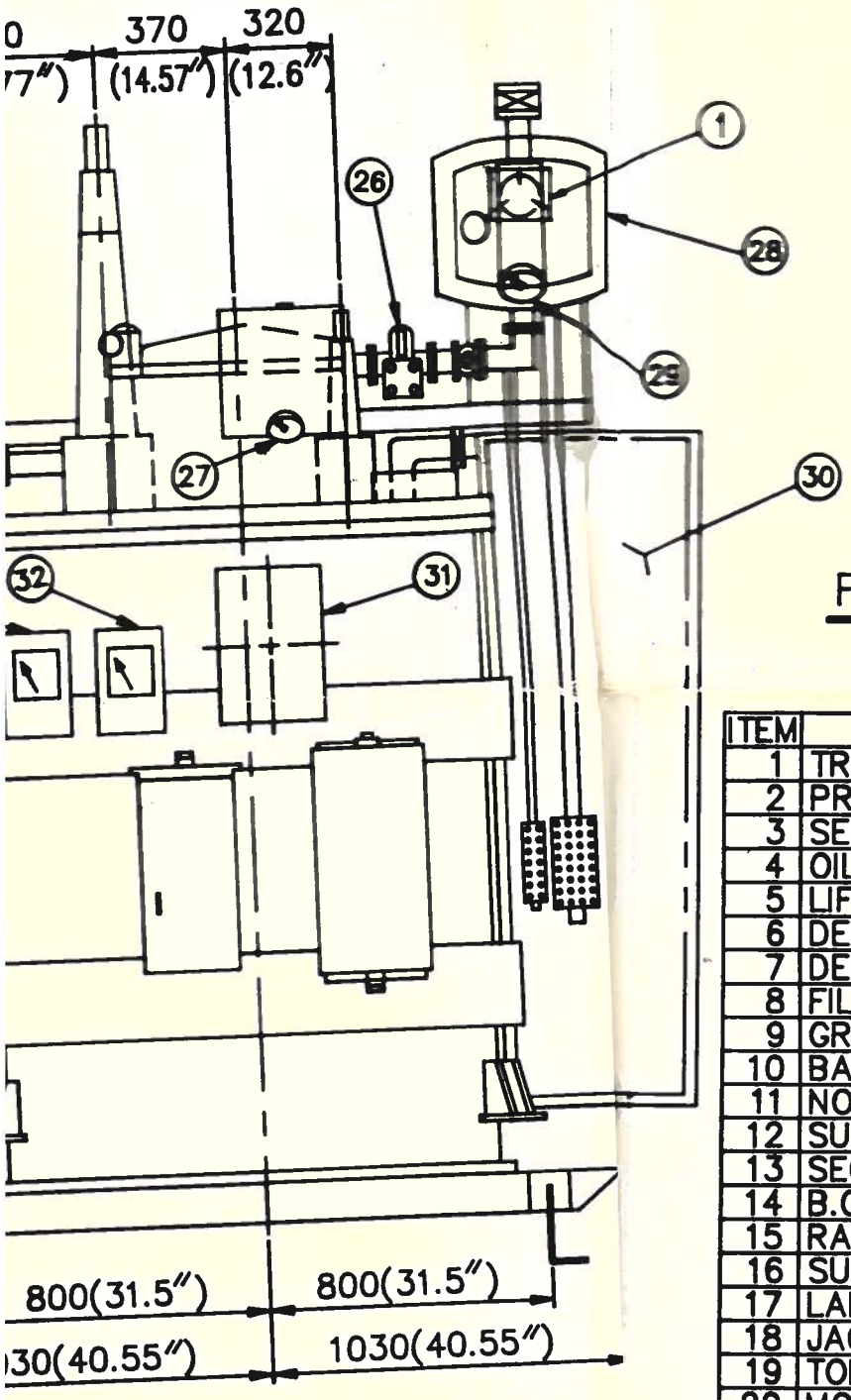
2.16 DIAL THERMOMETER(FOR WINDING TEMP.) ----------HIE-0230-84

2.17 SUDDEN OIL PRESSURE RELAY ----------HIE-0233-86

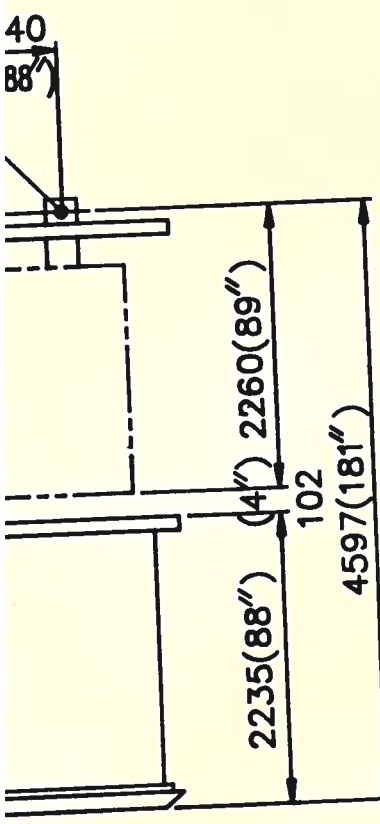
2.18 BUCHHOLZ' RELAY ----------HIE-0238-87

2.19 HANDLE OPERATING MECHANISM(FOR OFF-LOAD) ----------HIE-0319-85

END.



OW A DIRECTION VIEW



QUIRED FOR UNTANKING

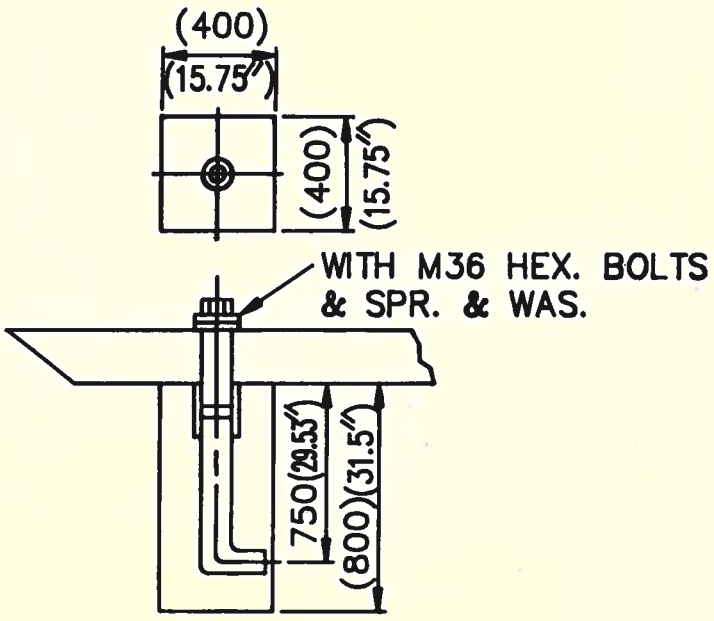


FIG. 1: DETAIL OF FOUNDATION BOLT

( ) IS HOLE SIZE OF FOUNDATION
(PREPARED BY CUSTOMER)

ITEM	DESCRIPTION
1	TRADE MARK
2	PRIMARY BUSHING
3	SECONDARY NEUTRAL BUSHING
4	OIL CONSERVATOR (FOR O.L.T.C.)
5	LIFTING LUGS (FOR TOTAL WEIGHT)
6	DEHYDRATING BREATHER (FOR O.L.T.C.)
7	DEHYDRATING BREATHER (FOR MAIN BODY)
8	FILTER AND DRAIN VALVE
9	GROUNDING PADS (2 EACH)
10	BASE
11	NO VOLTAGE TAP CHANGER
12	SUDDEN OIL PRESSURE RELAY
13	SECONDARY BUSHING
14	B.C.T. TERMINAL BOX
15	RADIATORS
16	SURGE ARRESTERS
17	LADDER
18	JACKING BOSSES
19	TOP FILTER VALVE
20	MOTOR DRIVE UNIT
21	TERMINAL BOX
22	PRESSURE RELIEF DEVICE
23	ON-LOAD TAP CHANGER
24	LIFTING LUGS (FOR COVER & CORE)
25	HAND HOLE
26	BUCHHOLZ'S RELAY
27	OIL GAUGE (FOR O.L.T.C.)
28	OIL CONSERVATOR (FOR MAIN BODY)
29	OIL GAUGE (FOR MAIN BODY)
30	COOLING FANS
31	NAME PLATE
32	DIAL THERMOMETER(FOR OIL TEMP.)
33	DIAL THERMOMETER(FOR WINDING TEMP.)

APPROXIMATE QUANTITY	
TOTAL WEIGHT	83700 *LB*
CORE & WINDINGS	36894 *LB*
TANK & FITTINGS	26047 *LB*
TOTAL OIL (2766 *GAL*)	20759 *LB*
FINISH	ANSI 45 LIGHT GREEN

RATING

TYPE	FREQUENCY (HZ)	CAPACITY (MVA)	TERMINAL VOLTAGE (KV) PRIMARY	TERMINAL VOLTAGE (KV) SECONDARY
HC/OP/O	60	15/20/25/28	F36220/F35360/R34500/F33640/F32780	13.8±10% (33 POINTS)

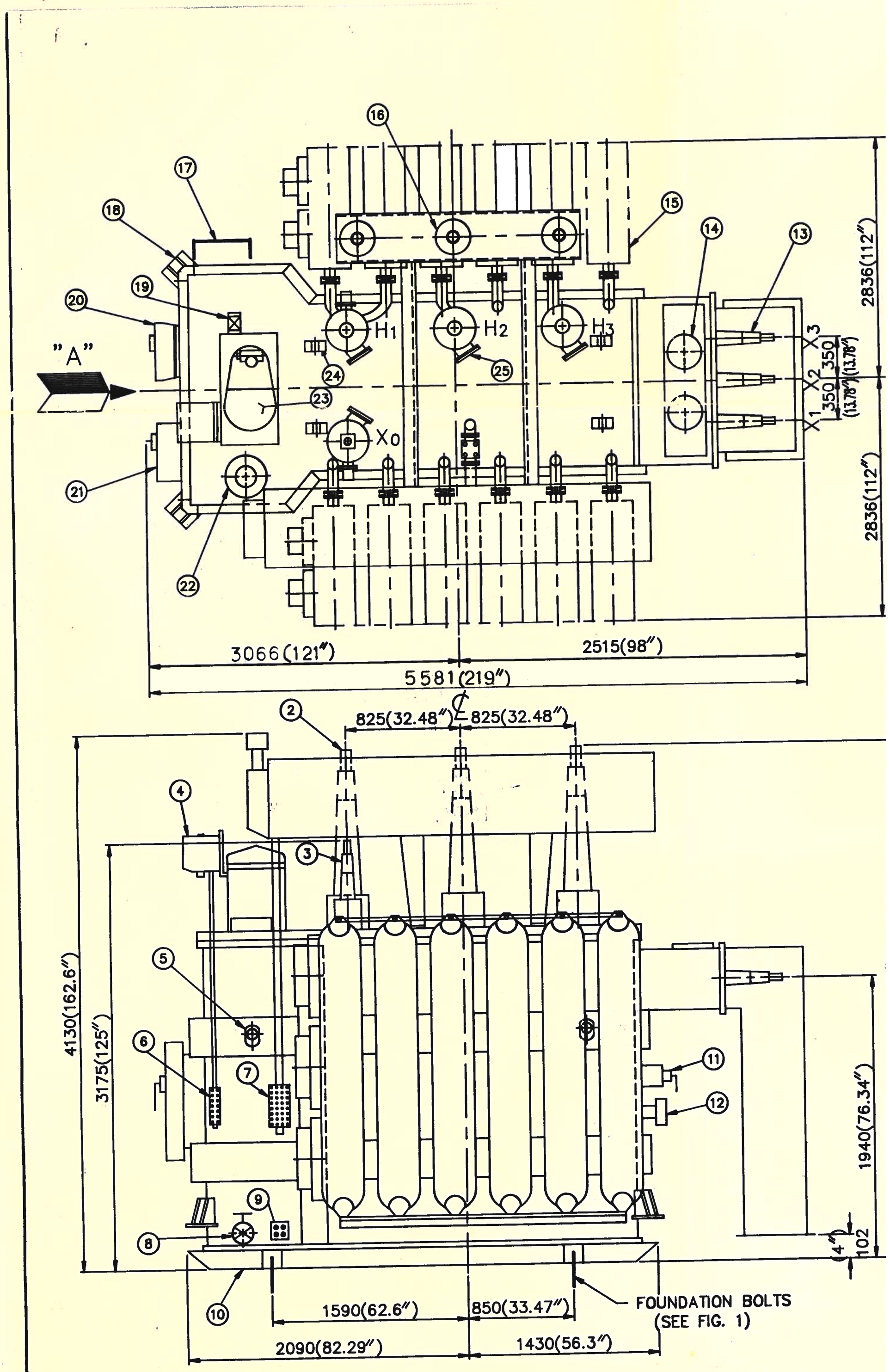
APPROVED BY	CHECKED BY	
J. Y. Chen Sep. 15 '88	S H Shyu Sep. 15 '88	OUTLINE OF THREE PHASE TRANSFORMER
DESIGNED BY	DRAWN BY	
	W. R. Lee Sep. 15, '88	

TATUNG CO.
TAIPEI THE REPUBLIC OF CHINA

452-08915

REGISTERED

G.P.A. P.O. NO. B800-01137

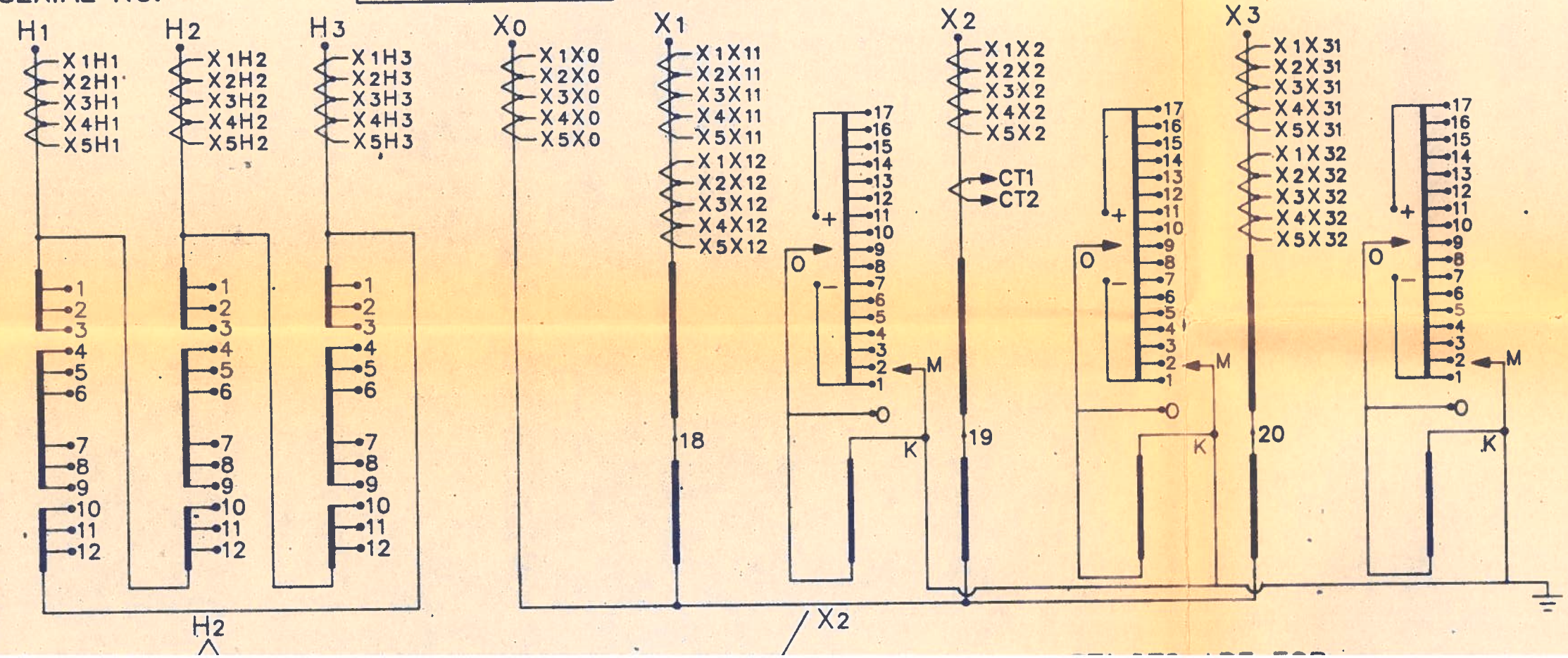


4–10ø HOLES
(0.4")

TRANSFORMER

TO AMERICAN STANDARD ANSI C57.12 1980

TYPE FORM		HC/OP/OPTLR		%IMPEDANCE(75℃) AT 15MVA	
CLASS		OA/FA/FA		IMPULSE LEVELS H.V. WINDING	200 BIL
PHASES		3		L.V. WINDING	110 BIL
FREQUENCY		60	Hz	L.V. WIND/NEUTRAL	110 BIL
MVA RATING		15/20/25/28		AMBIENT TEMPERATURE	40 ℃
VOLTAGE RATINGS	H.V.	34500	V	TEMPERATURE RISE	55 ℃
	L.V.	13800	V	ALLOWABLE VACUUM FOR TANK	−15 PSI
CURRENT RATINGS	H.V.	251/335/419/469	A	MAIN TANK OIL	GAL
	L.V.	628/837/1046/1172	A	TAP−CHANGER BOX OIL	GAL
UNTANKING WT.			lb	MFG. DATE	
TOTAL WT.			lb	MAXIMUM MVA 65 DEGREE C RISE---28 MVA	
SERIAL NO.					



(01) MATERIAL: SUS304CP(STAINLES
SURFACE FINISH: BLACK LETTE

(48")
(96")

TAP									
	X3X2–X4X2	X1X2–X2X2	X4X2–X5X2	X2X2–X3X2	X2X2–X4X2	X1X2–X3X2	X1X2–X4X2	X2X2–X5X2	X1X2–X5X2
	X3X31–X4X31	X1X31–X2X31	X4X31–X5X31	X2X31–X3X31	X2X31–X4X31	X1X31–X3X31	X1X31–X4X31	X2X31–X5X31	X1X31–X5X31
	X3X12–X4X12	X1X12–X2X12	X4X12–X5X12	X2X12–X3X12	X2X12–X4X12	X1X12–X3X12	X1X12–X4X12	X2X12–X5X12	X1X12–X5X12
	X3X32–X4X32	X1X32–X2X32	X4X32–X5X32	X2X32–X3X32	X2X32–X4X32	X1X32–X3X32	X1X32–X4X32	X2X32–X5X32	X1X32–X5X32

L.V. NEUTRAL B.C.T.										
RATIO	50:5A	100:5A	150:5A	200:5A	250:5A	300:5A	400:5A	450:5A	500:5A	600:5A
TAP	X2X0–X3X0	X1X0–X2X0	X1X0–X3X0	X4X0–X5X0	X3X0–X4X0	X2X0–X4X0	X1X0–X4X0	X3X0–X5X0	X2X0–X5X0	X1X0–X5X0

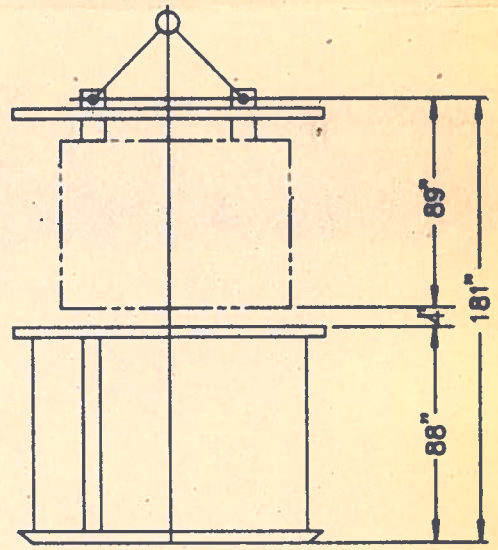
L.V. WINDING CONNECTIONS

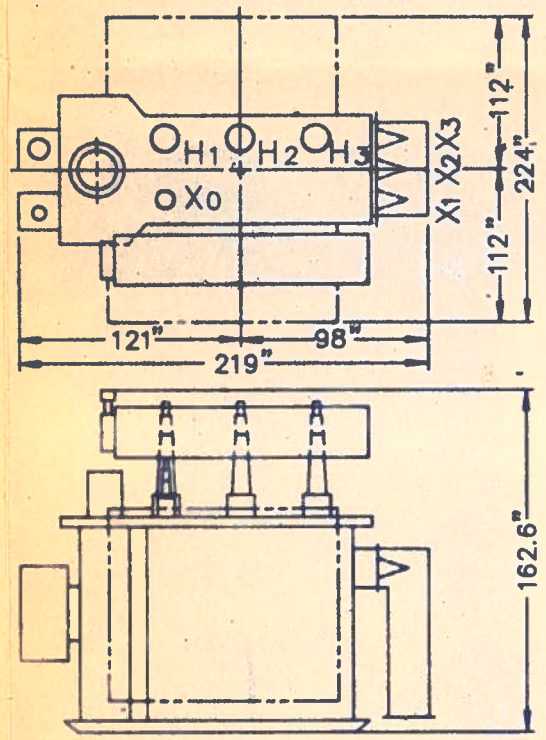
VOLTAGE (V)	CURRENT(A) 15 MVA	20 MVA	25 MVA	ON-LOAD TAP CHANGER CONNECTIONS TAP POS.	TAP SELECTOR M	REVERSING SWITCH O
15180	571	761	951	16R		17
15090	574	765	957	15R	16	
15010	577	769	962	14R		15
14920	580	774	967	13R	14	
14840	584	778	973	12R		13
14750	587	783	979	11R	12	
14660	591	788	985	10R		11
14580	594	792	990	9R	10	
14490	598	797	996	8R		9
14400	601	802	1002	7R	8	
14320	605	806	1008	6R		7
14230	608	811	1014	5R	6	
14150	612	816	1020	4R		5
14060	616	821	1027	3R	4	
13970	620	827	1033	2R		3
13890	624	831	1039	1R	2	
13800	628	837	1046	N	0	
13710	632	842	1053	1L	16	
13630	635	847	1059	2L		15
13540	640	853	1066	3L	14	
13460	644	858	1073	4L		13
13370	648	864	1080	5L	12	
13280	652	870	1087	6L		11
13200	656	875	1093	7L	10	
13110	661	881	1101	8L		9
13020	665	887	1109	9L	8	
12940	669	892	1115	10L		7
12850	674	899	1123	11L	6	
12770	678	904	1130	12L		5
12680	683	911	1138	13L	4	
12590	688	917	1146	14L		3
12510	692	923	1154	15L	2	
12420	697	930	1162	16L		1

H.V. WINDING CONNECTIONS LINES ON H1 H2 H3

VOLTAGE (V)	CURRENT(A) 15 MVA	20 MVA	25 MVA	OFF-CIRCUIT TAP CHANGERS TAP POS.	CONNECTIONS	
36220	240	319	399	1	3–4	9–10
35360	245	327	409	2	3–5	8–10
34500	251	335	419	3	2–5	8–11
33640	258	344	429	4	2–6	7–11
32780	265	353	441	5	1–6	7–12

*OFF-CIRCUIT TAP CHANGERS FOR DE-ENERGIZED OPERATION ONLY.





G.P.A. P.O. NO.B800-01137

TATUNG CO.

TAIWAN, THE REPUBLIC OF CHINA

451-01395

320(12.60")

350(13.78")

PLEASE FILL THE BLANKS OF THIS DRAWING ACCORDING TO THE NAMEPLATE MOUNTED ON THE TRANSFORMER

APPROVED BY: C.Y. Chen Sep. 15 '88
CHECKED BY: S.Y. Chen Sep. 15 '88
DESIGNED BY:
DRAWN BY: W.R. Lee Sep. 15 '88

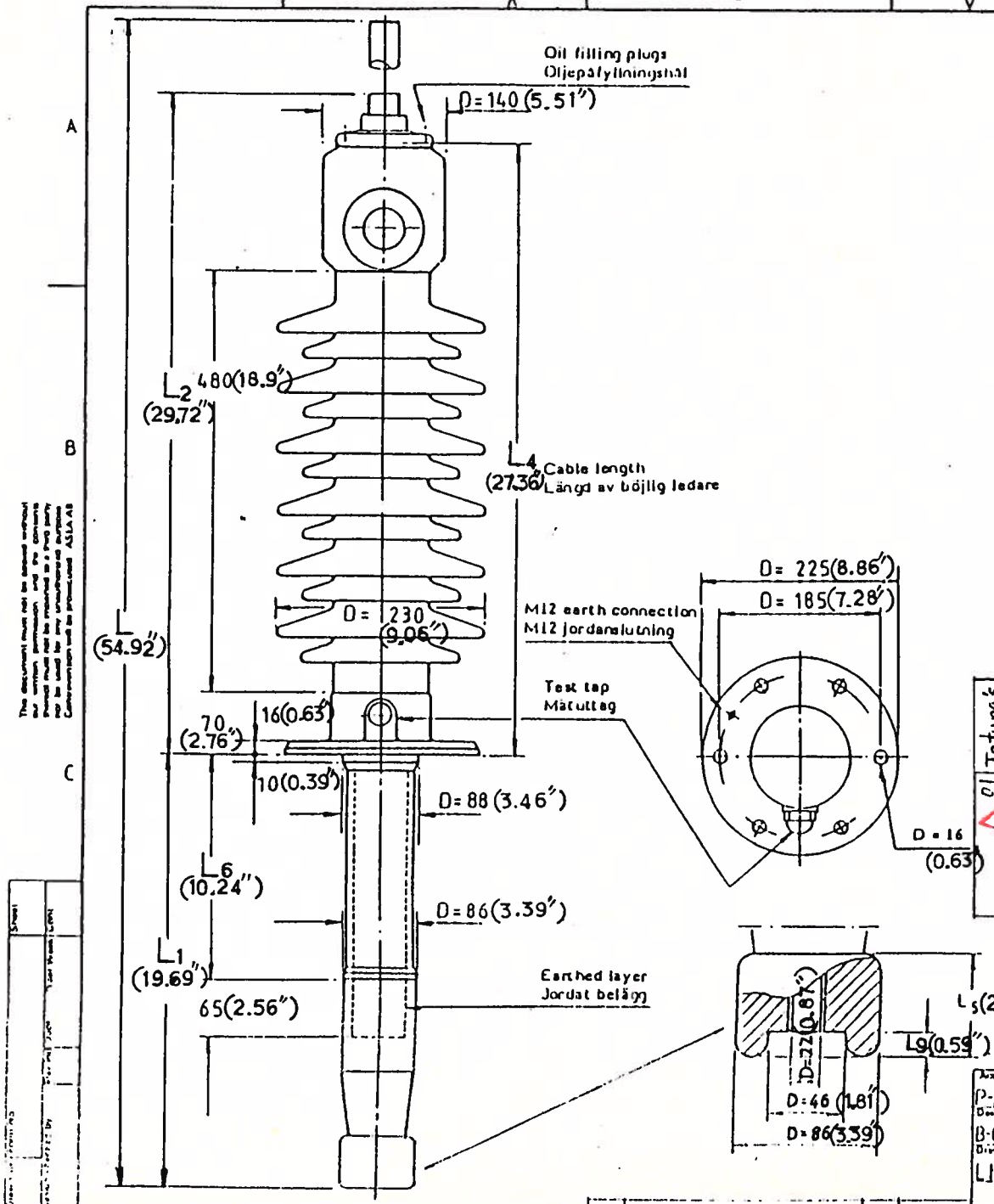
TATUNG CO. TAIPEI THE REPUBLIC OF CHINA

NAMEPLATE

451-01395

REGISTERED

G.P.A. P.O. NO.B800-01137



Type
Typ GOB 250

Nominal voltage Märkspänning		52 kV
Max phase-to-earth voltage Max spänning fas till jord		52 kV
Rated current of bushing Märkström för genomföring		800 A
Max current with solid conductor Max ström med massiv ledare		860 A
Max current with stranded cable Max ström med böjlig ledare		500 A
Lightning impulse Stötprov	1.2/50 µs	250 kV
Routine test voltage Rutinprov	1 min 50 Hz	120 kV
Wet AC test (IEC and ANSI) Vått växelspänningsprov		105 kV
Creepage distance Krypsträcka		1500 ± 60 mm

Terminals for cable according to 2751 237- 55
Anslutningar för kabel enligt

Terminals for solid conductor according to 2751 237- 58
Anslutningar för massiv ledare enligt

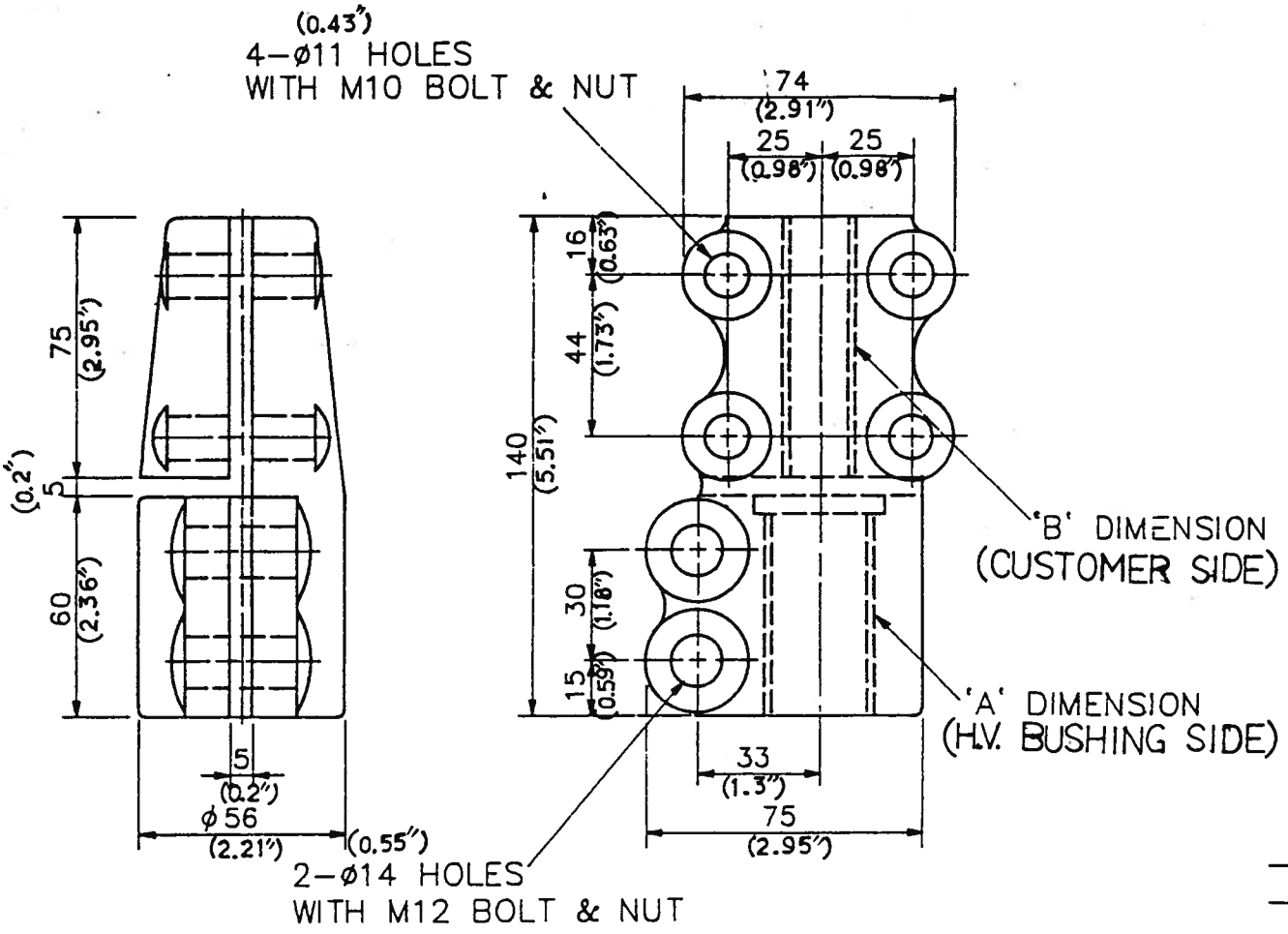
Tatung's Mat. No.	Catalogue No. Beställningsnr	Insulator/Isolant Brown Brun	 Light grey Ljusgrå	Dimensions/Mått mm L	L_1	L_2	L_4	L_5	L_6	L_9	Ma kg
01 02 03 04	LF 123 171	-K (01)	-L (02)	1135	240	755	695	60	-	15	24
		-M	-N	1185	290	755	695	110	-	65	24
	LF 123 173	-K (03)	-L (04)	1395	500	755	695	60	260	15	26
		-M	-N	1445	550	755	695	110	260	65	26
	LF 123 175	-K	-L	1595	700	755	695	60	460	15	28
		-M	-N	1645	750	755	695	110	460	65	28

( ) Tatung's Material No.

454-79280

NO SCALE

Accepted by qual. control P-A Thunander	Accepted for prod by B Hall	Description (English) BUSHING GOB 250
Design checked by B-O Stenestam	Drawn by CIA	Description (own language) GENOMFÖRING GOB 250
Drawing checked by L Holmström	Issued by Dept / Year / Week ZKLT 84 26	2751 237 – 29
ASEA		Rev. Ind. Sheet 1 Cont. –



NO	A	B
01	M27X2	50~250mm²
02	M36X3	50~250mm²
03	M27X2	50~325mm²
04	W0.75–16	50~250mm²
05	ø30 HOLE (1.18")	50~250mm² (0.08") (0.39")

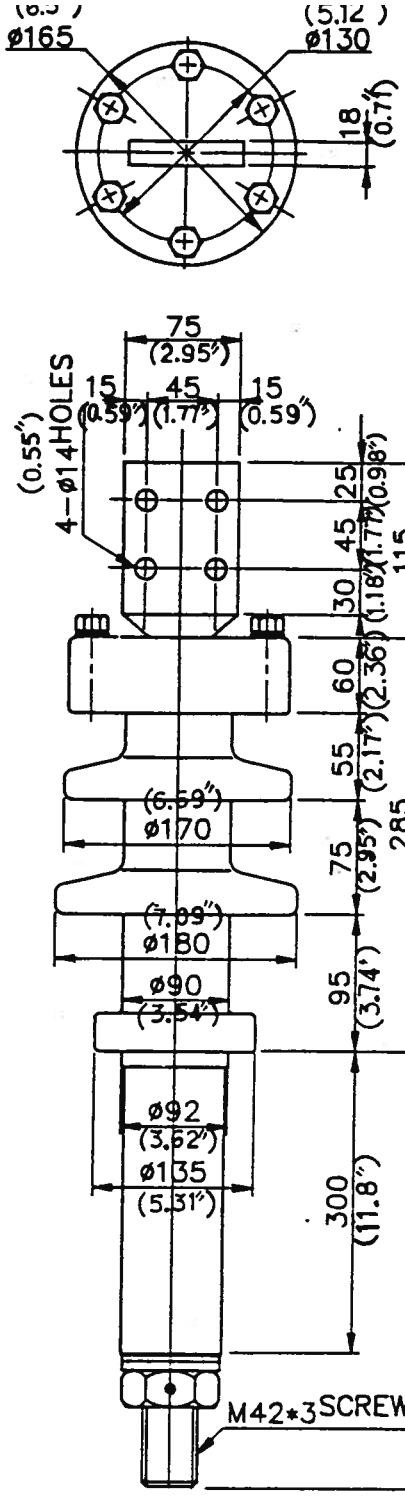
MATERIAL : BOLT–STAINLESS STEEL
TERMINAL– COPPER JS SILVER–PLATED.
NUT–STAINLESS STEEL

APPROVED BY	CHECKED BY	
T. Y. [illegible] July 27 '87	T. R. Chang July 27th '87	OUTLINE OF TERMINAL
DESIGNED BY	DRAWN BY	
	M. Y. Kuo July 27 '87	

TATUNG CO.
TAIPEI THE REPUBLIC OF CHINA

454–53754

REGISTERED



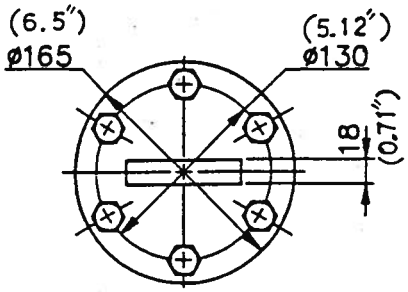
- Rated Current: 2000 A
- BIL: 110 KV
- ACTV: 50 Kv/1min(Dry)
- Color: BLUE GRAY
- Creepage Distance 400 mm (15.75")
- MATERIAL: TERMINAL----- COPPER IS SILVER-PLATED.

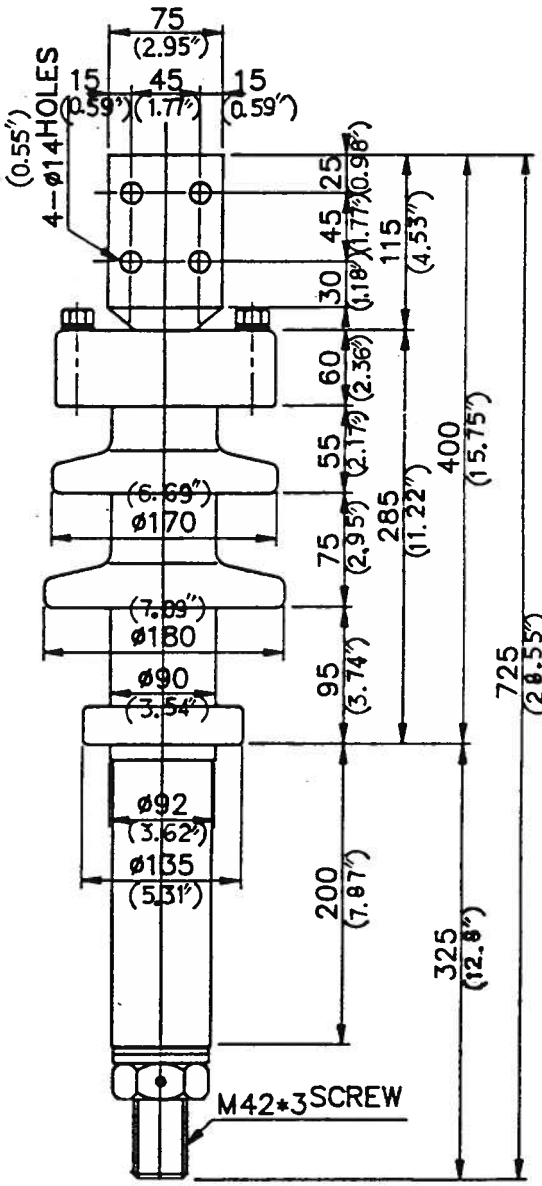
APPROVED BY	CHECKED BY	
J.Y. Chen	J. Yu	
DESIGNED BY	DRAWN BY	OUTLINE OF BUSHING
	M.Y. Kuo	SBN-10-30-2000A

TATUNG CO.
TAIPEI THE REPUBLIC OF CHINA

454-79239

REGISTERED



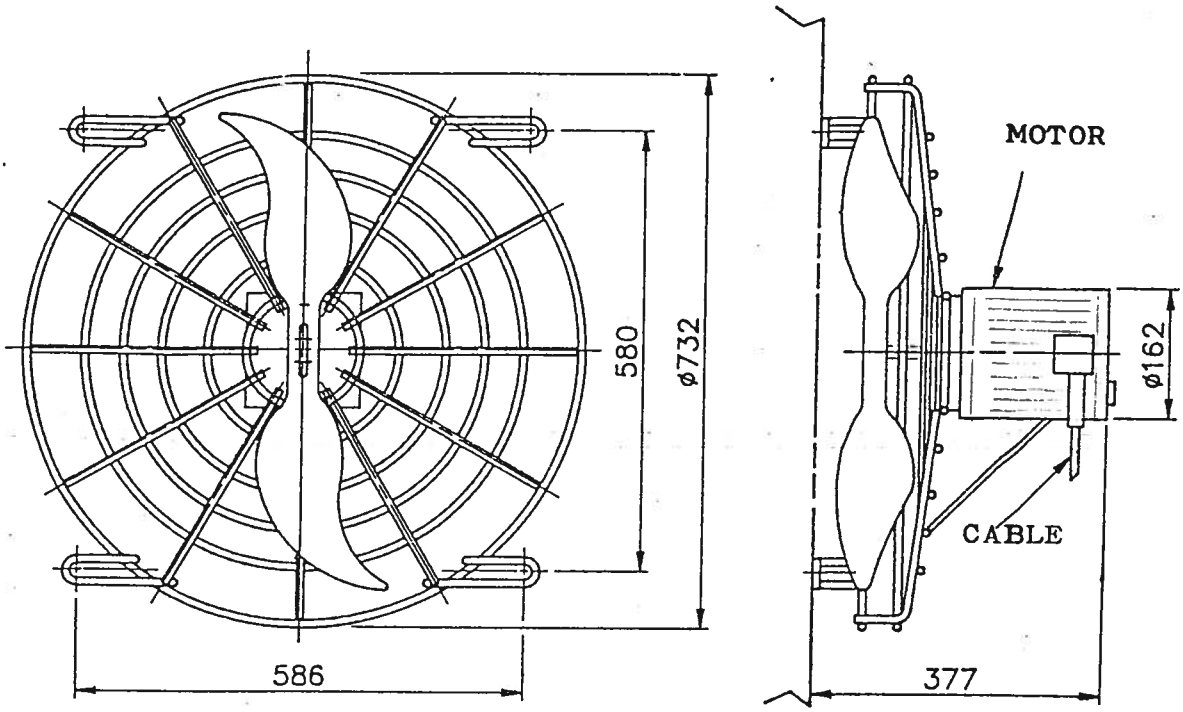


- Rated Current: 2000 A
- BIL: 110 KV
- ACTV: 50 Kv/1min(Dry)
- Color: BLUE GRAY
- Creepage Distance 400 mm (15.75")
- MATERIAL: TERMINAL ----- COPPER IS SILVER-PLATED.

APPROVED BY	CHECKED BY	
J.Y. Kuo Jan. 21 '87	T.R. Chang Jan 21. '87	
DESIGNED BY	DRAWN BY	OUTLINE OF BUSHING
	M. Y. Kuo Jan. 20 '87	SBN-10-20-2000A

TATUNG CO.
TAIPEI THE REPUBLIC OF CHINA

454-79119



TYPE FORM	SW6PF	POLES	6
OUTPUT	1/4HP	CAPACITY	130 m^3/min
VOLTAGE	1ϕ 120/240V	AIR VELOCITY	6.1 m/sec
FREQUENCY	60 HZ.	PROPELLER MAT.	GLASS-POLYESTER

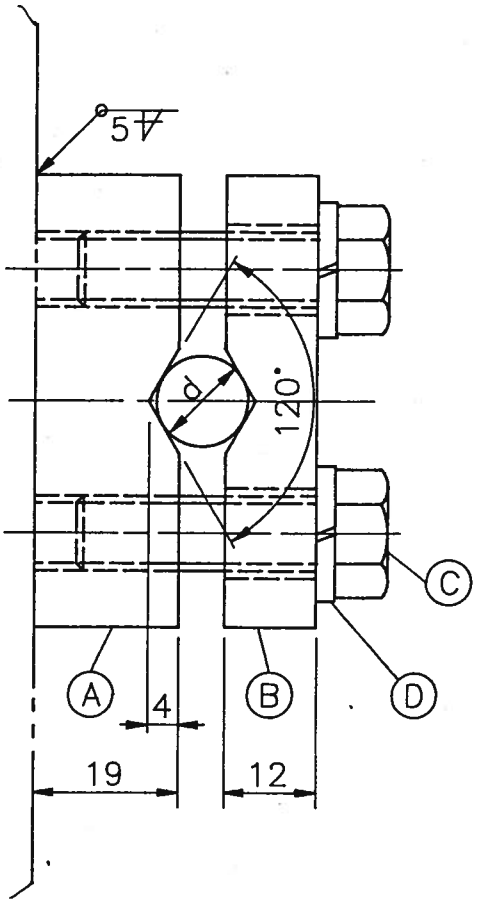
PAINTING

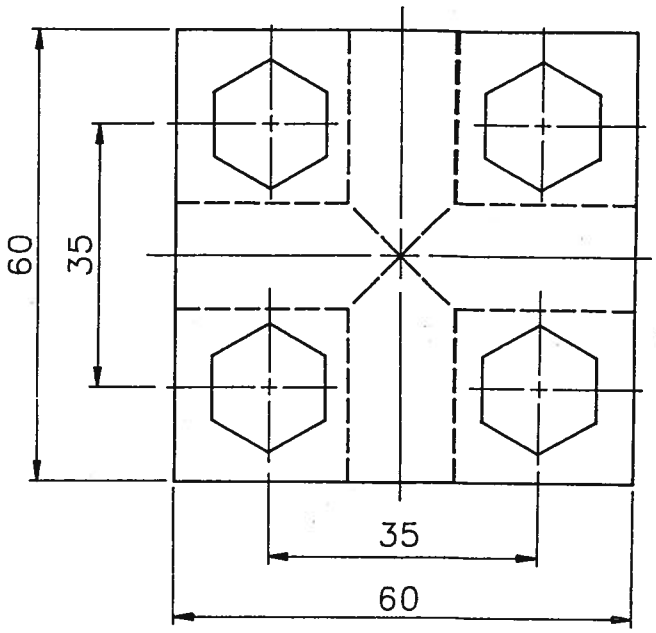
	ANSI 45 (light green)
	MUNSELL 2.3PB3.5/3.9 (blue gray)

APPROVED BY	CHECKED BY	
J.Y. Chen Sep 13 '88		OUTLINE OF COOLING FAN
DESIGNED BY	DRAWN BY	
	S. Yeh Sep. 13, '88	

TATUNG CO.
TAIPEI THE REPUBLIC OF CHINA

454-79282





SUITABLE FOR CONDUCTOR : 150mm²~250mm².

DIAMETER OF CONDUCTOR (d) : ø16.1~ø20.7mm.

	LIST	MATERIAL
A	GROUNDING PAD	SS41
B	CLAMP PAD	COPPER ALLOY
C	HEXAGONAL HEAD BOLTS	M10 SUS304
D	SPRING LOCK WASHER	M10S (#2)

DIMENSION IN mm.

APPROVED BY	CHECKED BY	
		EARTHING TERMINAL (GROUNDING PAD)
DESIGNED BY	DRAWN BY	
S.H. Shyu May. 31 '78	S.H. Shyu May. 31 '78	
TATUNG CO.		454–76325

Surge Arresters

VariSTAR® Type AZF Intermediate-Class (IEC 10-kA, Light-Duty Pressure-Relief Class A)

COOPER INDUSTRIES
McGRAW-EDISON POWER SYSTEMS
235-70

GENERAL

The McGraw-Edison VariSTAR® Type AZF intermediate-class arrester (Figures 1 and 2) incorporates the latest in metal-oxide varistor (MOV) technology. In addition to the elimination of gaps and the resulting improvement in surge protection, the Type AZF arrester utilizes a pressure-venting system unparalled in the industry for intermediate-class arresters. The Type AZF arrester has achieved a 40-kA station-class arrester pressure-relief capability — extending its application range to include installations where increased fault-current levels exist.

CONSTRUCTION

External

The Type AZF intermediate arrester is available in two design configurations — a metal-top design for ratings 9/10 through 120 kV and a porcelain-top design for ratings 3/4.5 through 27 kV. All units are designed with aluminum base castings which incorporate an 8.75" (22.2 cm) bolt-circle mounting diameter. This allows complete physical interchangeability with existing intermediate-class designs.

The Type AZF arrester housing, utilizing Munsell 5BG 7.0/0.4 light gray-wet process porcelain, provides dielectric strength and high external creepage and arcing distances. Cantilever strength is 33,000 in-lbs.

All metal-top units can either be base or suspension mounted. Ratings above 39 kV require stacking of lower rated units and come complete with both individual nameplates as well as a stacking nameplate.

Porcelain-top units are ideally suited for confined spaces — such as cubicle mounting — where clearances between live parts are critical.

Electrical Connections

Two "L-shaped" electrical connectors, one ground and one line terminal, are supplied with porcelain-top arresters rated 3/4.5 through 27 kV and metal-top arresters rated 9/10 through 72 kV. The ground terminal connector is also used on arresters rated 90 kV through 120 kV, while the line terminal (top) connector on these arresters is an integral part of the top cap on the grading-ring assembly. The line and ground terminals include connector clamps that accommodate No. 6 solid through 500 mcm (13.3mm² through 253mm²) stranded copper or aluminum conductor.

To allow for closer mounting spacing in enclosures, the top "L-shaped" terminal assembly and reinforcing plate is removable on all porcelain-top VariSTAR Type AZF arresters rated 3/4.5 through 27 kV. For these applications, a separate "U-shaped" line lead terminal clamp accommodating conductor sizes from No. 6 solid through No. 1/0 stranded (13.3mm² through 53.5mm²) is supplied.

Internal

Because of the highly non-linear nature of McGraw-Edison's VariSTAR disk, the Type AZF intermediate-class arrester is constructed without series gaps. The elimination of gaps provides a significant improvement in surge protection because the arrester responds quicker to surge waves without the usual wait associated with the gap sparkover characteristic. The elimination of gaps also improves the arrester's resistance to external contamination.

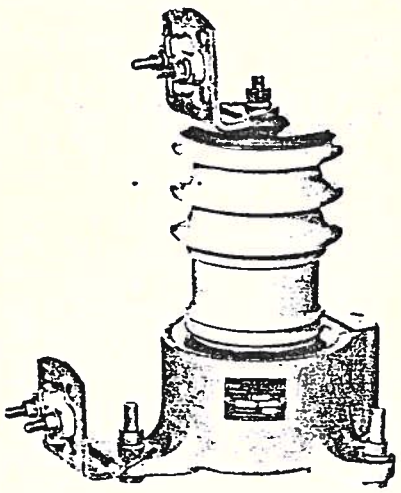


Figure 1.
9/10 kV VariSTAR Type AZF porcelain-top arrester.

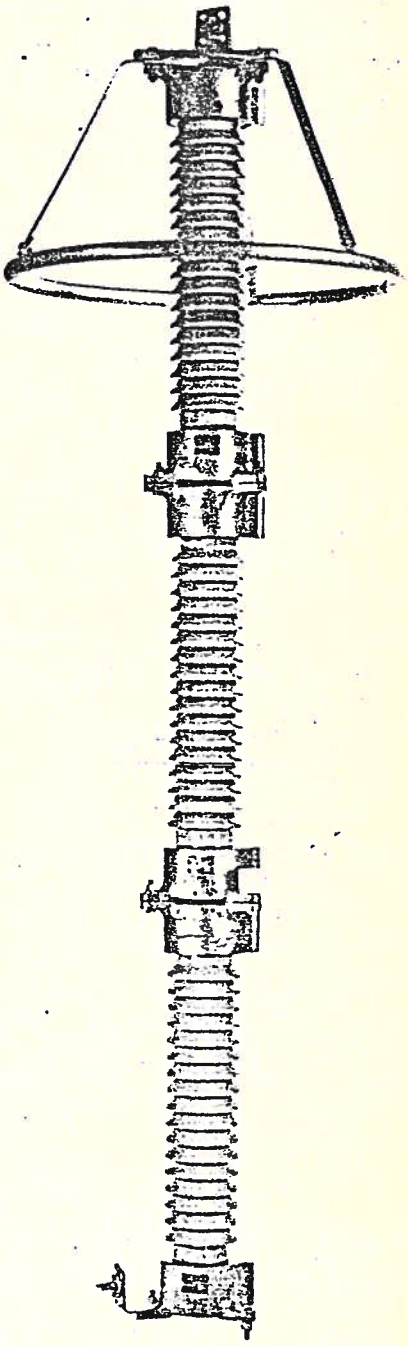


Figure 2.
120 kV VariSTAR Type AZF metal-top arrester.

FEATURES AND DETAILED DESCRIPTION

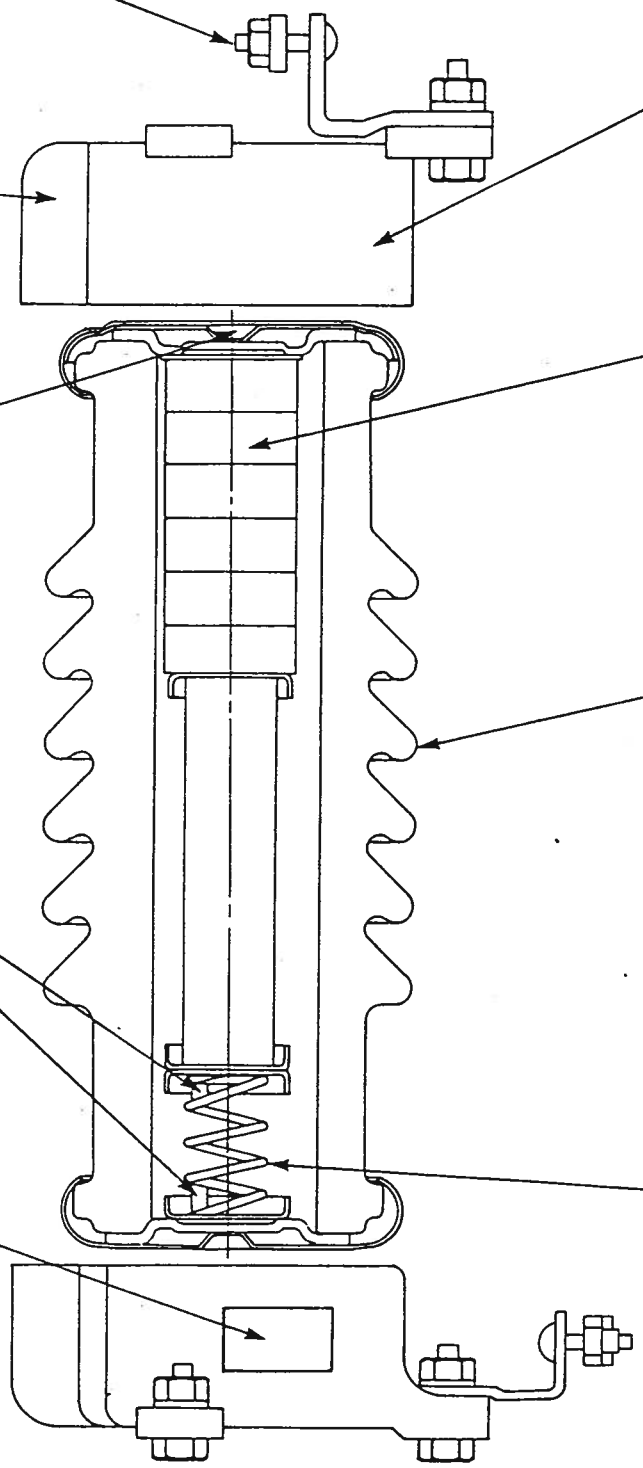
TERMINALS WITH TIN-PLATED CLAMPS
Connector furnished takes No. 6 solid through 500-mcm stranded conductors.

DIRECTIONAL VENTS
Built into casting to assure transfer of fault arc safely outside damaged arrester.

PRESSURE-SENSITIVE DIAPHRAGM
Vents damaged arresters before internal pressure reaches dangerous proportions.

DESSICANT
Insures dry atmosphere by absorbing ambient moisture entrapped during assembly.

IDENTIFICATION INFORMATION
Provides convenient reference for arrester type, voltage rating, pressure-relief rating, year and quarter of manufacture. Information is clearly marked on nameplate which is secured to bottom casting.



ALUMINUM-ALLOY END CASTINGS
Contribute to light weight; provide a sturdy base for stacking and mounting on various structures.

MOV DISK
Highly non-linear metal-oxide varistor provides superior surge protection.

HIGH-STRENGTH, WET-PROCESS GLAZED PORCELAIN
Withstands thermal and mechanical shocks; excellent washing characteristics; deep skirts provide high creepage distance.

HEAVY STEEL COIL SPRING
Maintains high pressure on MOV disks providing effective contact interfaces. Protects internal parts from mechanical shocks or vibrations.

Figure 3.
VariSTAR Type AZF construction features.

2

OPERATION

The operation of a VariSTAR® Type AZF intermediate-class arrester differs from that of a conventional gapped-type arrester. Like a conventional graded-gap direct-connected arrester, minimal leakage current is conducted by the Type AZF arrester at nomrla operating voltages. When an overvoltage condition occurs, a VariSTAR arrester limits the overvoltage to the required protection level by conducting the surge current. Unlike conventional arresters, the Type AZF arrester does not conduct power-follow current. The totally gapless VariSTAR AZF arrester absorbs only the minimum energy required to provide the desired protection. VariSTAR AZF arresters are ideal for protection against repeated high-energy switching-surge discharges and provides superior protection for applications such as capacitor banks, multiple lines, and cable circuits.

Metal-oxide technology allows a significant reduction of all external dimensions resulting in improved pressure-relief capability of the Type AZF arrester. Surpassing the ANSI IEEE C62.1-1981 requirements for intermediate-class arresters to vent 16 kA fault currents without violent porcelain rupture. The Type AZF arrester has successfully passed the 0.2 second pressure-relief test with currents through 40 kA (rms symmetrical).

PRODUCTION TESTS

A complete production test program assures a quality product. Every VariSTAR disk is tested for V_1ma, leakage current and 10-kA discharge voltage. Quality is further assured by a series of destructive tests performed on every batch of disks. Each completed AZF arrester must pass leakage current and RIV tests at MCOV and at rated voltage. In addition the seal integrity of every arrester is checked with a helium mass spectrometer leak test — detecting leaks as small as 3 x 10^8 standard cm^3 of helium per second.

STANDARDS

McGraw-Edison has tested the Type AZF arrester in accordance with the appropriate sections of the existing standards for gapped-type silicon-carbide intermediate arresters. In addition, tests suitable for MOV arresters, consistent with tests under development have also been performed.

The Type AZF arrester meets the applicable sections of the latest revisions of the following performance standards:

ANSI/IEEE C62.1
IEC 99-1 including Pressure-Relief Class A
CSA C233
BS 2914
AS 1307

Table 1
Recommended Arrester Applications for the Type AZR Arrester

System Voltage (kV) Line to Line)		Recommended Arrester Rating (kV)	
Nominal	Maximum	Three Wire or Four Wire Wye Solidly Grounded Neutral	Delta and Ungrounded Wye
2.4	2.52	3/4.5	3 4.5
4.16	4.37	3/4.5	6 7.5
4.8	5.04	3/4.5	6 7.5
6.9	7.25	6/7.593/10	
8.32	8.74	6/7.5	9 10
12.0	12.7	9/10	12 15
12.47	13.2	9/10	15
13.2	13.97	9/10 12	15
13.8	14.5	9/10 12	15
20.78	21.8	15 21	24
22.9	24.2	18 21	24
24.9	26.4	18 21	24 27
34.5	36.5	27 30	36 39
46	48.3	36 39	48
69	72	54 60	72
115	121	90 96	108 120
138	145	108 120	—
161	169	120	—

* Preferred arrester rating for this system voltage.

GENERAL APPLICATION RECOMMENDATIONS

The rating of an arrester is the power-frequency, line-to-ground voltage at which the arrester is designed to pass an operating duty-cycle test. Table 1 provides a general application guide for the selection of the proper arrester rating for a given system voltage and system grounding configurations.

McGraw-Edison application engineers are available to make specific application recommendations. The following information is normally required:

1. System maximum operating voltage.
2. System grounding conditions.
   For three-wire circuits, grounding conditions depend upon whether the system is solidly grounded at the source, grounded through neutral impedance at the source, grounded through transformers, or ungrounded. Where unusual conditions exist (high ground resistance, high capacitive load, arc-welding equipment, etc.) the following supplementary information is necessary:
   A. A general description of unusual condition.
   B. Type of construction, phase spacing, length of line, conductor size.
   C. BIL of equipment and line insulation.
   D. Phase-sequence components of impedances on the source side of the arrester location.
   The impedance of the transformer and the impedance and grounding of supply to the substation affect the voltage during faults.
3. Available fault current.
4. Maximum line-to-ground voltage during faults and overvoltage duration.
5. Unusual environmental conditions (temperature and contamination).

TEMPORARY OVERVOLTAGE (TOV) CAPABILITY

The temporary overvoltage (TOV) capability of the VariSTAR® Type AZF intermediate-class arrester has been tested and is shown in Figure 4. At rating (1.0 per unit) and above, the curve includes the energy input to the device during a duty-cycle test. Between MCOV and rating (0.84 p.u. to 1.0 p.u.), the curve shows the long-term capability reflecting the most severe duty. Under actual system conditions the TOV capability can be expected to be greater than indicated by the curve. However, overvoltage excursions will not significantly degrade the life of the arrester as long as the TOV curve is not exceeded.

PERFORMANCE CHARACTERISTICS

See Table 2 and Table 3 for insulation characteristics and Table 4 for protective characteristics for Type AZF intermediate-class arresters.

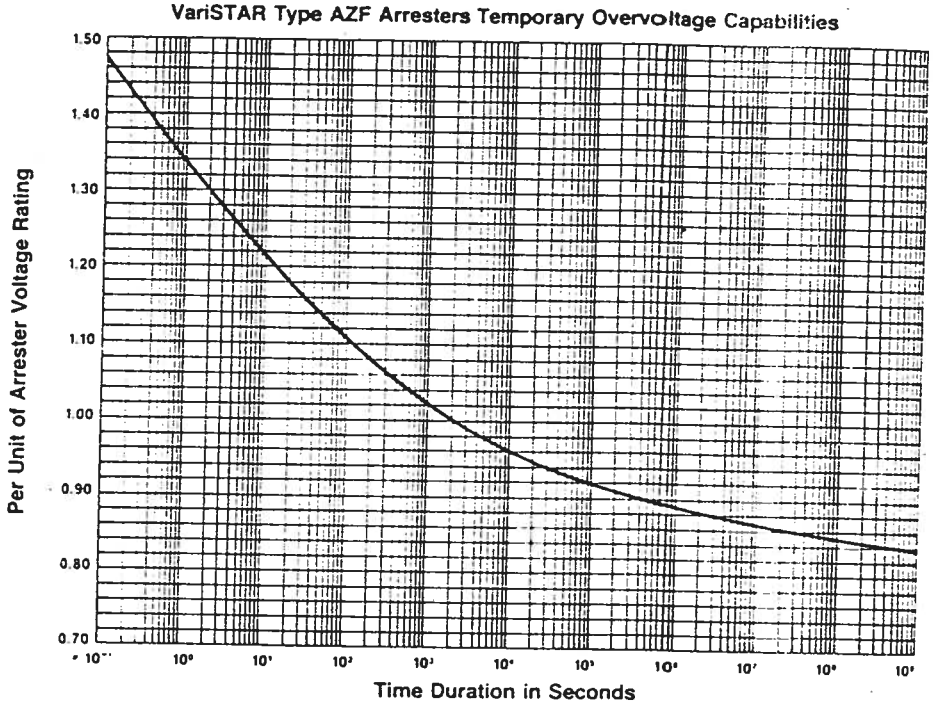


Figure 4.
Temporary overvoltage curve.

Table 2
Insulation Characteristics — for Metal-Top Type AZF Arrester (AZF1A)

Arrester Rating (kV rms)	Creepage Distance		Arcing Distance		Minimum Impulse Withstand (kV crest)		Minimum Power-Frequency Wet Withstand (kV crest)	
	in.	cm	in.	cm	ANSI	AZF	ANSI	AZF
9 10	15.8	40.0	9.5	24.1	95	105	30	85
12	15.8	40.0	9.5	24.1	110	120	45	95
15	15.8	40.0	9.5	24.1	110	150	45	100
18	25.0	63.5	14.5	36.8	150	175	60	105
21	25.0	63.5	14.5	36.8	150	200	60	115
24	25.0	63.5	14.5	36.8	150	230	60	120
27	32.2	81.9	18.0	45.7	200	250	80	130
30	32.2	81.9	18.0	45.7	200	270	80	140
33	32.2	81.9	18.0	45.7	200	300	80	145
36	41.0	104.1	23.0	58.4	200	325	80	150
39	41.0	104.1	23.0	58.4	250	330	100	160
45	50.0	127.0	29.0	73.6	250	410	100	180
48	50.0	127.0	29.0	73.6	250	440	100	190
60	64.5	163.8	36.0	91.4	296 *	540	124 **	220
72	82.0	208.0	46.0	116.8	346 *	650	145 **	255
90	96.8	245.8	54.0	137.2	444 *	800	185 **	300
96	105.5	267.8	59.0	149.9	468 *	850	196 **	320
108	123.0	312.4	69.0	175.3	529 *	960	221 **	350
120	123.0	312.4	69.0	175.3	590 *	1060	246 **	380

* Minimum 1.2 x 50 microsecond impulse-withstand voltage is determined by multiplying 20 kA discharge voltage (8 x 20 microsecond wave) as prescribed by paragraph 8.1.3. (a-B) of ANSI IEEE C62.1-1981 by 1.42.

** Minimum power-frequency, wet-withstand voltage is determined by multiplying switching surge discharge voltage (1.50 x 300 microsecond wave) as prescribed by paragraph 8.1.3. (2-B) of ANSI IEEE C62.1-1981 by 0.82.

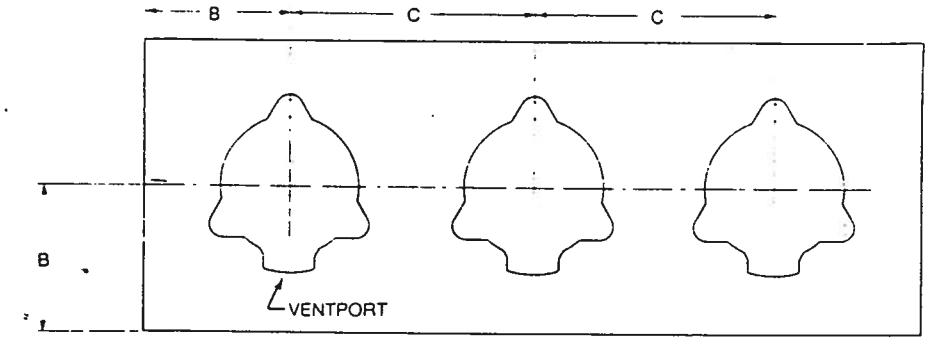
Table 3
Insulation Characteristics — for Porcelain-Top Type AZF Arrester (AZF2A)

Arrester Rating (kV rms)	Creepage Distance		Arcing Distance		Minimum Impulse Withstand (kV crest)		Minimum Power-Frequency Wet Withstand (kV crest)	
	in.	cm	in.	cm	ANSI	AZF	ANSI	AZF
3 4.5	8.5	21.6	5.5	14.0	60	105	20	40
6 7.5	8.5	21.6	5.5	14.0	75	105	24	40
9 10	8.5	21.6	5.5	14.0	95	105	30	40
12	11.0	27.9	6.8	17.3	110	120	45	50
15	11.0	27.9	6.8	17.3	110	120	45	50
18	13.4	34.0	8.1	20.6	110	135	45	55
21	15.9	40.4	9.4	23.9	150	155	60	65
24	19.1	48.6	10.1	25.7	150	160	60	65
27	19.1	48.6	10.1	25.7	150	160	60	65

Table 4
Protective Characteristics

Voltage Rating (kV)	MCOV (kV)	Equivalent Front-of-Wave (kV crest)	Discharge Voltage for an 8 x 20 Microsecond Current Wave (kV crest)						Maximum Switching-Surge Protective Level ** (kV crest)
			1.5 kA	5 kA	10 kA	20 kA	40 kA	65 kA	
3/4.5	3.0	20	14.4	15.8	17.4	19.1	22.2	25.3	13.8
6/7.5	6.0	30	21.7	23.8	26.1	28.7	33.3	38.0	20.8
9/10	8.4	38	27.3	30.0	33.0	36.3	42.1	48.0	26.2
12	10.1	48	34.1	37.5	41.2	45.3	52.5	59.9	32.7
15	12.6	58	41.0	45.0	49.5	54.5	63.2	72.1	39.4
18	15.2	63	45.2	49.7	54.6	60.1	69.7	79.5	43.4
21	17.7	86	61.5	67.6	74.3	81.7	94.8	108.1	59.0
24	20.2	96	68.3	75.1	82.5	90.8	105.3	120.0	65.6
27	22.7	100	71.1	78.1	85.8	94.4	109.5	124.8	68.3
30	25.2	109	77.5	85.2	93.6	103.0	119.5	136.2	74.4
33	27.8	124	88.5	97.2	106.8	117.5	136.3	155.4	85.0
36	30.3	134	95.3	104.7	115.0	126.5	146.7	167.2	91.5
39	32.8	153	109.3	120.1	132.0	145.2	168.4	192.0	104.9
45	37.8	172	122.6	134.7	148.0	162.8	188.8	215.2	117.7
48	40.4	182	129.9	142.7	156.8	172.5	200.1	228.1	124.7
60	50.4	217	155.1	170.4	187.2	205.9	238.8	272.2	148.9
72	60.5	267	190.5	209.3	230.0	253.0	293.5	334.6	182.9
90	75.6	326	232.5	255.5	280.8	308.9	358.3	408.5	223.2
96	80.7	351	250.3	275.0	302.2	332.4	385.6	439.6	240.3
108	90.8	400	285.7	314.0	345.0	379.5	440.2	501.8	274.3
120	100.8	460	328.0	360.4	396.0	435.6	505.3	576.0	314.9

* Based on discharge voltage for a 10-kA impulse current wave producing an arrester voltage crest occurring in 0.6 microseconds.
** Based on switching-surge coordination current of 1000 amps (150 x 300 microsecond wave).



VALUES FOR B AND C DIMENSIONS ARE SHOWN IN TABLE 5 OR FIGURE 9.

Figure 6.
Three-phase in-line mounting.

Table 5
Catalog Number, Dimensions, and Clearances for Porcelain-Top Type AZF Arresters

Arrester Rating (kV)	Catalog Number	Dimensions						Net Weight of Units	
		A		B		C			
		Arrester Height *		Minimum Phase-to-Ground **		Minimum Phase-to-Phase ***			
		in.	cm	in.	cm	in.	cm	lb.	kg
3/4.5	AZF2A3	12.3	31.2	5.2	13.2†	9.0	22.9	20.4	9.5
6/7.5	AZF2A6	12.3	31.2	5.2	13.2††	9.0	22.9	20.4	10.0
9/10	AZF2A10	12.3	31.2	5.2	13.2	9.0	22.9	23.6	10.7
12	AZF2A12	13.6	34.5	5.2	13.2	9.0	22.9	25.9	11.8
15	AZF2A15	13.6	34.5	7.2	18.3	9.0	22.9	27.4	12.4
18	AZF2A18	14.9	37.8	8.0	20.3	9.0	22.9	29.6	13.4
21	AZF2A21	16.8	42.7	9.2	23.4	11.5	29.2	33.1	15.0
24	AZF2A24	18.8	47.8	10.0	25.4	12.5	31.8	34.9	15.9
27	AZF2A27	18.8	47.8	10.0	25.4	12.5	31.8	36.8	16.7

* Dimension A from Figure 8.
** Dimension B from Figure 6.
*** Dimension C from Figures 6 and 7.
† Minimum phase-to-ground spacing from metal portion of top terminal is 2.4" (6.1cm).
†† Minimum phase-to-ground spacing from metal portion of top terminal is 3.6" (9.1cm).

ORDERING INFORMATION

Figure 5 shows the bolt locations for the Type AZF arrester base-mounting. Figures 6 and 7 show the recommended three-phase mounting configurations and minimum clearances for the Type AZF arrester. VariSTAR Type AZF porcelain-top designs are detailed in Table 5 and Figure 8. Type AZF metal-top designs are itemized in Figure 9.

Note: McGraw-Edison lists recommended minimum clearances; however, national, state, or local codes may dictate a wider spacing.

CAUTION
The pressure-relief vents must be directed away from adjacent equipment to limit potential damage to the equipment in the event of arrester failure.

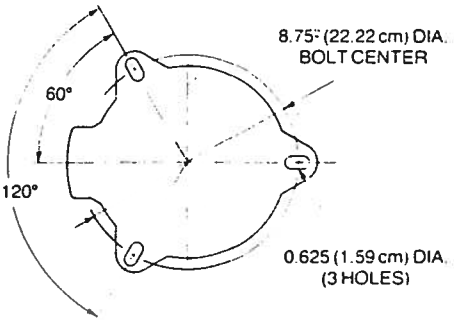
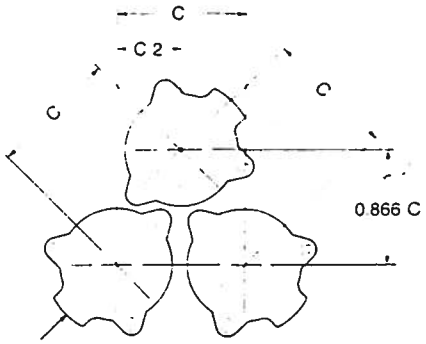


Figure 5.
Mounting bolt locations.



VALUES FOR C DIMENSIONS ARE SHOWN IN TABLE 5 OR FIGURE 9.

Figure 7.
Three-phase triangular mounting.

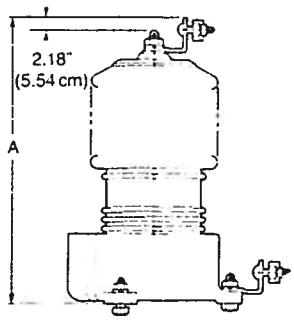
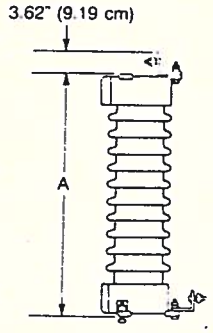


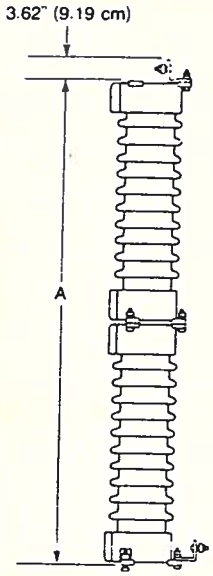
Figure 8.
Type AZF arrester rated 3/4.5 through 27 kV.

5

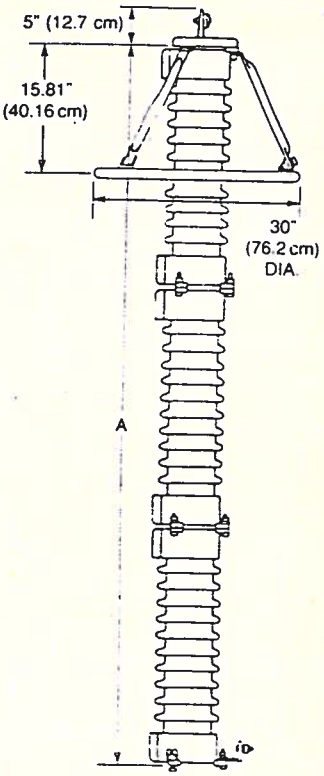
RATINGS AND DIMENSIONS



TYPE AZF ARRESTER RATED 9 10 THROUGH 39kV



TYPE AZF ARRESTER RATED 45 THROUGH 72kV.



TYPE AZF ARRESTER RATED 90 THROUGH 120kV

Arrester Rating (kV)	Catalog Number	Dimensions						Net Weight of Units	
		A		B		C			
		Arrester Height *		Minimum Phase-to-Ground **		Minimum Phase-to-Phase ***			
		in.	cm	in.	cm	in.	cm	lb.	kg
9/10	AZF1A10	17.7	45.0	8.0	20.3	12.0	30.5	28.0	12.7
12	AZF1A12	17.7	45.0	8.0	20.3	12.0	30.5	29.0	13.2
15	AZF1A15	17.7	45.0	10.0	25.4	14.0	35.6	30.0	13.6
18	AZF1A18	22.7	57.6	10.0	25.4	14.0	35.6	35.5	16.1
21	AZF1A21	22.7	57.6	15.0	38.1	19.0	48.3	37.5	17.0
24	AZF1A24	22.7	57.6	16.0	40.6	20.0	50.8	38.5	17.5
27	AZF1A27	26.4	67.0	18.0	45.7	22.0	55.9	42.5	19.3
30	AZF1A30	26.4	67.0	18.0	45.7	22.0	55.9	43.5	19.8
33	AZF1A33	26.4	67.0	18.0	45.7	22.0	55.9	49.0	22.3
36	AZF1A36	31.4	79.8	20.0	50.8	25.0	63.5	50.0	22.7
39	AZF1A39	31.4	79.8	21.0	53.3	26.0	66.6	52.0	23.6
45	AZF1A45	52.9	134.3	23.0	58.4	28.0	71.1	66.0	30.0
48	AZF1A48	49.1	124.7	24.0	61.0	29.0	73.7	67.0	30.4
60	AZF1A60	52.9	134.3	29.0	73.7	34.0	86.4	87.0	39.5
72	AZF1A72	62.9	159.7	33.0	83.8	38.0	96.5	100.0	45.4
90	AZF1A90	79.3	201.4	51.0	129.5	68.0	172.7	130.0	59.0
96	AZF1A96	84.3	214.1	53.0	134.6	70.0	177.8	137.0	62.3
108	AZF1A108	94.3	239.5	58.0	147.3	74.0	188.0	150.0	68.2
120	AZF1A120	94.3	239.5	62.0	157.5	79.0	200.7	156.0	70.9

* Dimension A from Figure 9.
** Dimension B from Figure 6.
*** Dimension C from Figures 6 and 7.

Figure 9.
Catalog Number, Dimensions, and Clearances for Metal-Top Type AZF Arresters.

COOPER INDUSTRIES
McGRAW-EDISON
POWER SYSTEMS

The following machines, and tools are required for installing and assembling the transformer.

(1) Carrying and lifting equipment

Item	Description	Quantity	Remarks
Mobile crane	Cap. 50 tons. Lift 10 m	1	For bushings conservator radiators
Wire rope		1 set	
Shackle	More than 1 ton	1 set	For lifting bushings
Winch, roller etc.		1 set	For transfering main tank
Journal jack	More than tons		For jacking main tank

(2) Miscellaneous

Nail pullers, wrecking bars, canvas sheets, benzine, sand paper, cotton cloth, etc.

(3) Testing instruments

Item	Description	Quantity
Circuit tester		1
A.C. Voltmeter	Range 150/300 V 75/150 V	1 1
A.C. Ammeter	Range 10/5/1 A	1
Voltage regulator	0 40 V, 5 A	1
Megger	500 V	1
	2000 V	1
Dry cell	6 V	1

APPROVED BY	CHECKED BY	DRAWEN BY		HEAVY ELECTRIC APPARATUS FACTORY
J. Y. Chen	S.H. Shay	W. R. Lee		
Mar. 17. '89	Mar. 17'89	Mar. 17, 89		

TATUNG CO.

ITEM	PARTS	DESCRIPTION	Q'TY
1	H.V. BUSHING	ASEA LF-123173-K(INCLUDE OIL GAUGE)	1
2	L.V. BUSHING	453-25429-92	1
3	DIAL THERMOMETER (FOR OIL TEMP.)	AKM-34-40-01-19X-5.0	1
4	DIAL THERMOMETER (FOR WINDING TEMP.)	AKM-35-40-01-19X-5.0 (INCLUDE THERMAL RESISTOR)	1
5	DIAL OIL GAUGE	DIAMETER 160ϕ	1
6	DEHYDRATING BREATHER	CAPACITY 2000G.	1
7	PARKING		1
8	PL	30ϕ AC120V/18V 60HZ "W" "G" "R" "O"	2PCS 2PCS 2PCS 2PCS
9	D-FUSE	500V 2A	4PCS
10	AUX-RY	COIL AC120V 60HZ 4AC W/BASE OMRON LY4	4PCS
11	TIME-RY	COIL AC 120V 60HZ 0～10S W/BASE PMH-M-10M-AC120V	2PCS
12	FI	DC 125V(MAKER:TATUNG)	3PCS
13	LIGHT	AC 120V 60HZ 60W(MAKER:PHILIP)	2PCS

APPROVED BY	CHECKED BY	DRAWN BY		HEAVY ELECTRIC APPARATUS PLANT
J.Y. Chen	S.H. Shyu	W.R. Lee		
Dec. 20 '88	Dec. 20' 88	Dec. 20, 88		

TATUNG CO.

ORDER NO. 787401

CUSTOMER GUAM POWER AUTHORITY 28MVA ULTC

TU028MB001

ELEMENTARY DIAGRAMS

1	INDEX OF DRAWING.	21	
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G.P.A. P.O. NO. B800-01137

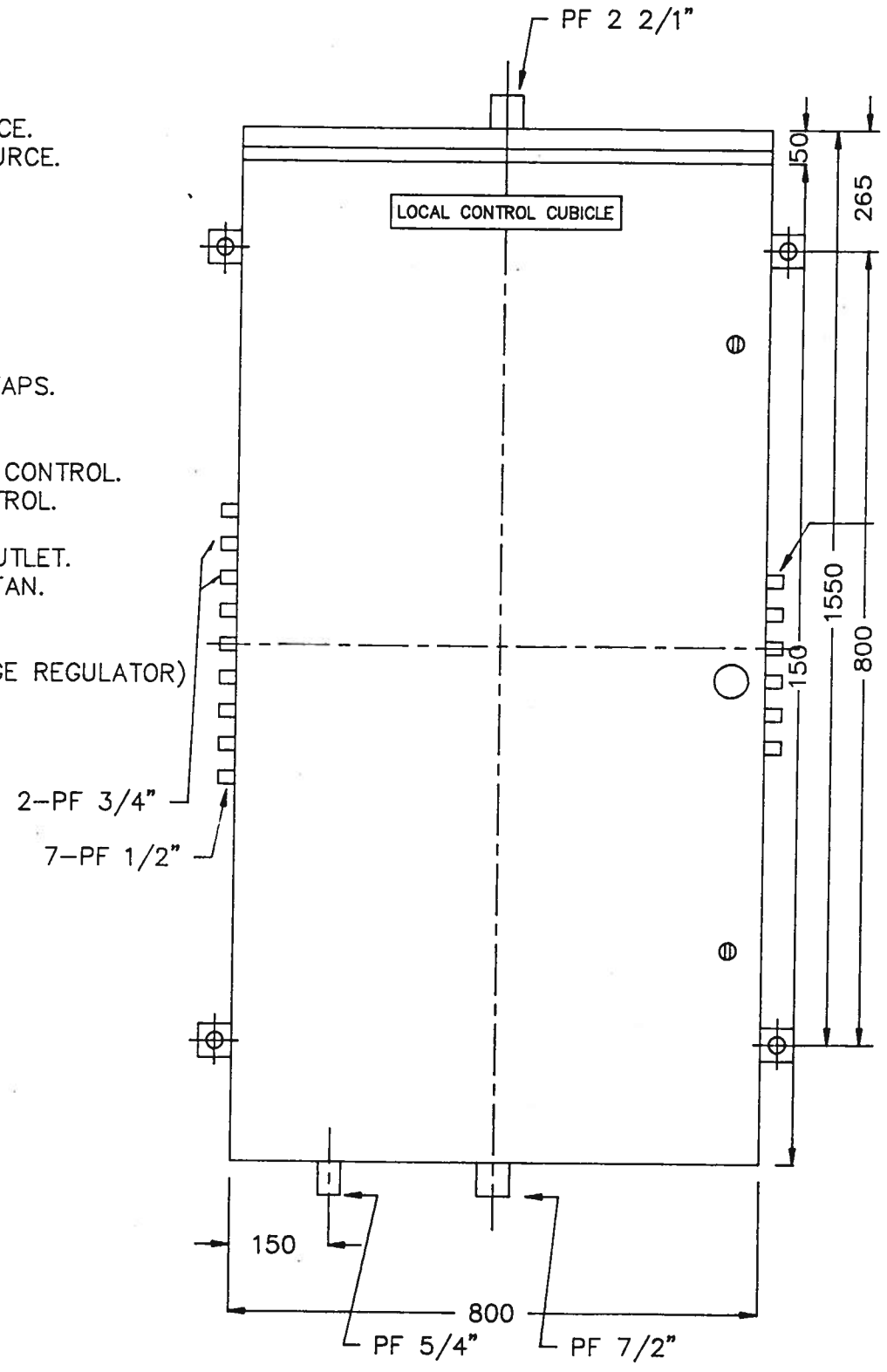
APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY	INDEX OF DRAWING
E. Z. Yeh		AVICTOR-Tsai		

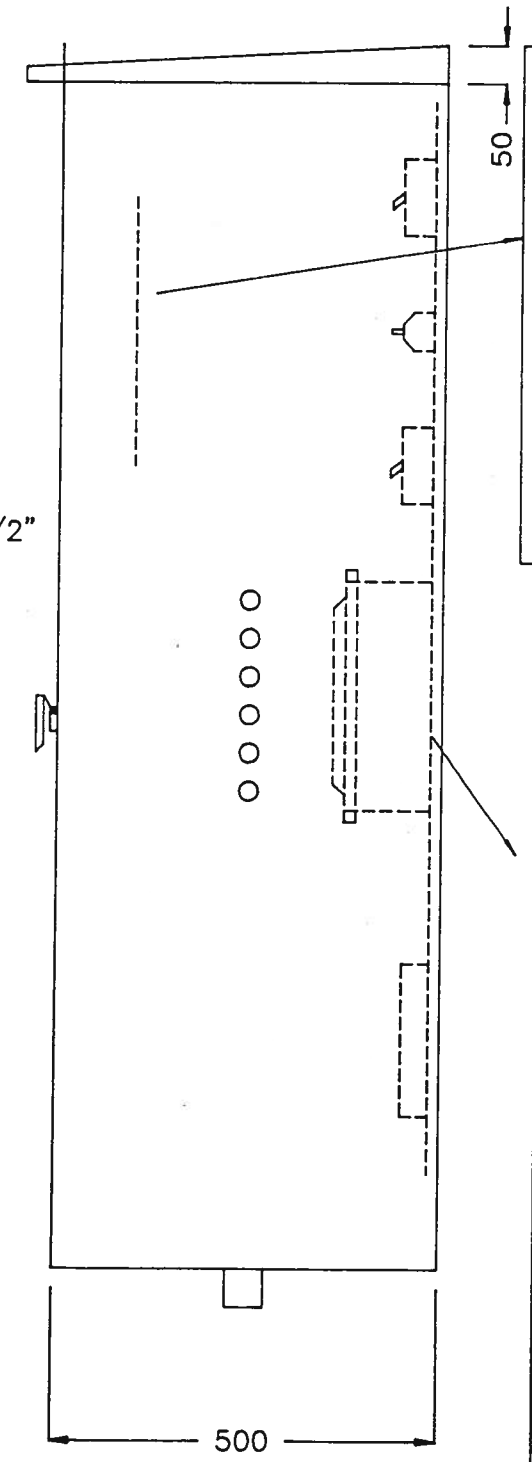
DESCRIPTION

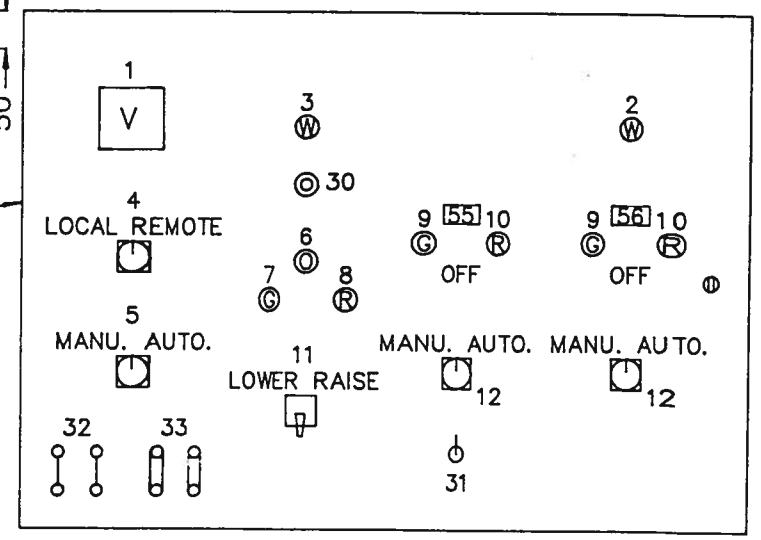
1. VOLTAGE METER.
2. LAMP FOR POWER SOURCE.
3. LAMP FOR CONTROL SOURCE.
4. CHANGE OVER SWITCH.
5. CHANGE OVER SWITCH.
6. LAMP FOR TAP RUNING.
7. LAMP FOR POWER LIMIT.
8. LAMP FOR HIGHT LIMIT.
9. LAMP FOR COOLER OFF.
10. LAMP FOR COOLER ON.
11. CONTROL SWITCH FOR TAPS.
12. CHANGE OVER SWITCH.
13. NFB FOR MAIN POWER.
14. NFB FOR MOTOR DRIVE CONTROL.
15. NFB FOR COOLING CONTROL.
16. NFB FOR HEATING.
17. NFB FOR LIGHTING & OUTLET.

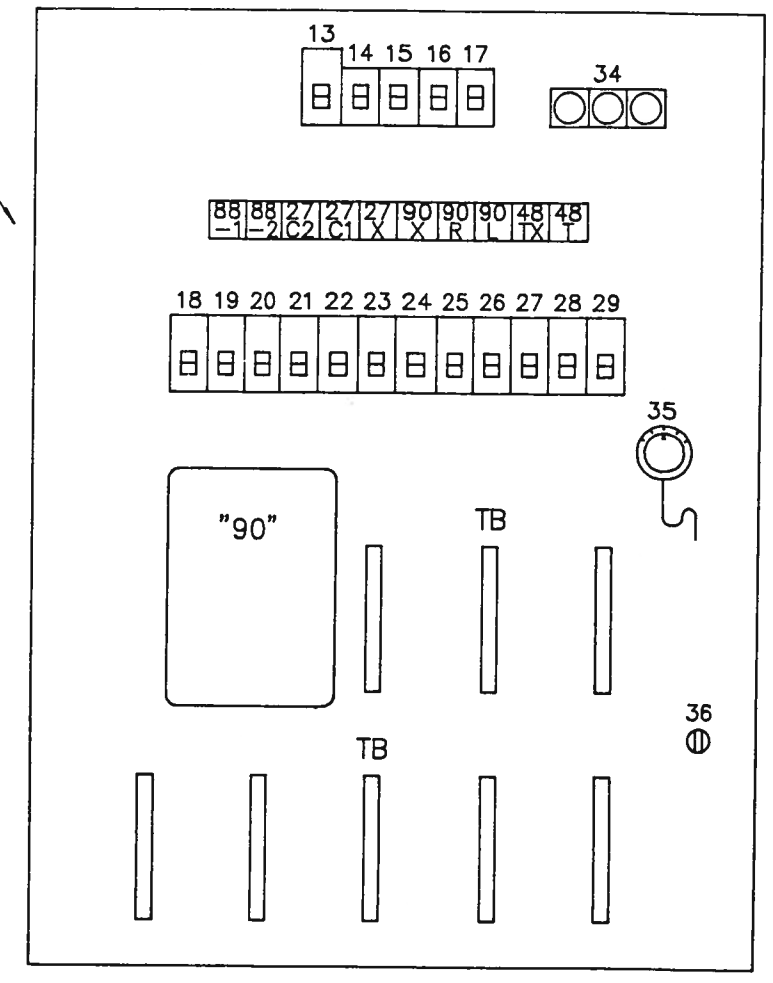
18~29. NFB FOR COOLING FAN.

30. RESET PUSH BUTTON.
31. LIGHTING SWITCH.
90. AVR(AUTOMATIC VOLTAGE REGULATOR)
TB. TERMINAL BROCKER.
32. PTT.
33. CTT.
34. D-FUSE.
35. THERMOSTAT.
36. OUTLET.









G.P.A.P.O.NO.B800-01137

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY
E.Z.Yeh		Victor-Tsai	吳金玉
Nov. 1, '88		oct-14-'88	78-03-17
REGISTERED			

G.P.A 28MVA LOCAL CONTROL CUBICLE OUTLINE DIAGRAM

478-02165-02

REVISION

1 • 2 • 3 • 4 • 5 • 6 • 7 • 8 • 9 •

A • B • C • D • E • F •

POWER SOURCE
1Ø AC120V
60HZ

PVC 38mm²

RW TW

R T

"LOCAL CONTROL CUBICLE"

W
SL1

PVC 22 mm²

F1
2A

NFB20AT5KA
R31
T31 TO HEATER (TO SH-05)

NFB
8M
20AT
5KA
R21
T21 TO MOTOR DRIVE CONTROL (TO SH-06)

NFB
8H
20AT 5KA
R22
T22 TO COOLING FAN CONTROL (TO SH-04)

NFB20A5KA
R41
T41 TO LIGHTING & OUTLET (TO SH-05)

27C1
271
272
TO ALARM

NFB
52M
75AT
5KA

R1

T1

PVC 8 mm²

PVC 8 mm²

MC
88-1
35A

MC
88-2
35A

PVC 3.5mm²

R11

T11

R12

T12

NFB 52-1 10AT 5KA
NFB 52-2 10AT 5KA
NFB 52-3 10AT 5KA
NFB 52-4 10AT 5KA
NFB 52-5 10AT 5KA
NFB 52-6 10AT 5KA
NFB 52-7 10AT 5KA
NFB 52-8 10AT 5KA
NFB 52-9 10AT 5KA
NFB 52-10 10AT 5KA
NFB 52-11 10AT 5KA
NFB 52-12 10AT 5KA

1FR 1FT 2FR 2FT 3FR 3FT 4FR 4FT 5FR 5FT 6FR 6FT 7FR 7FT 8FR 8FT 9FR 9FT 10FR 10FT 11FR 11FT 12FR 12FT

F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12

FAN MOTOR 1Ø 120V/240V 60HZ

REVISION				

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY
E. Z. Yeh		ANITA R-TSAI	Auto-cad
NOV-1-'88		OCT-14-'88	77-09-14
REGISTERED			

G.P.A 28MVA COOLING FAN
MAIN CIRCUIT

478-02165-03

GPA PO NO.2800-01137

ORDER NO. 787401

CUSTOMER GUAM POWER AUTHORITY 28MVA ULTC

TU028MB001

ELEMENTARY DIAGRAMS

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18		38	
19		39	
20		40	

G.P.A. P.O. NO. B800-01137

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY	INDEX OF DRAWING
E. Z. Yeh		AVICTOR-Tsai		
Nov. 1-88	— —	OCT 14-88	— —	478-02165-01

DESCRIPTION

1. VOLTAGE METER.
2. LAMP FOR POWER SOURCE.
3. LAMP FOR CONTROL SOURCE.
4. CHANGE OVER SWITCH.
5. CHANGE OVER SWITCH.
6. LAMP FOR TAP RUNING.
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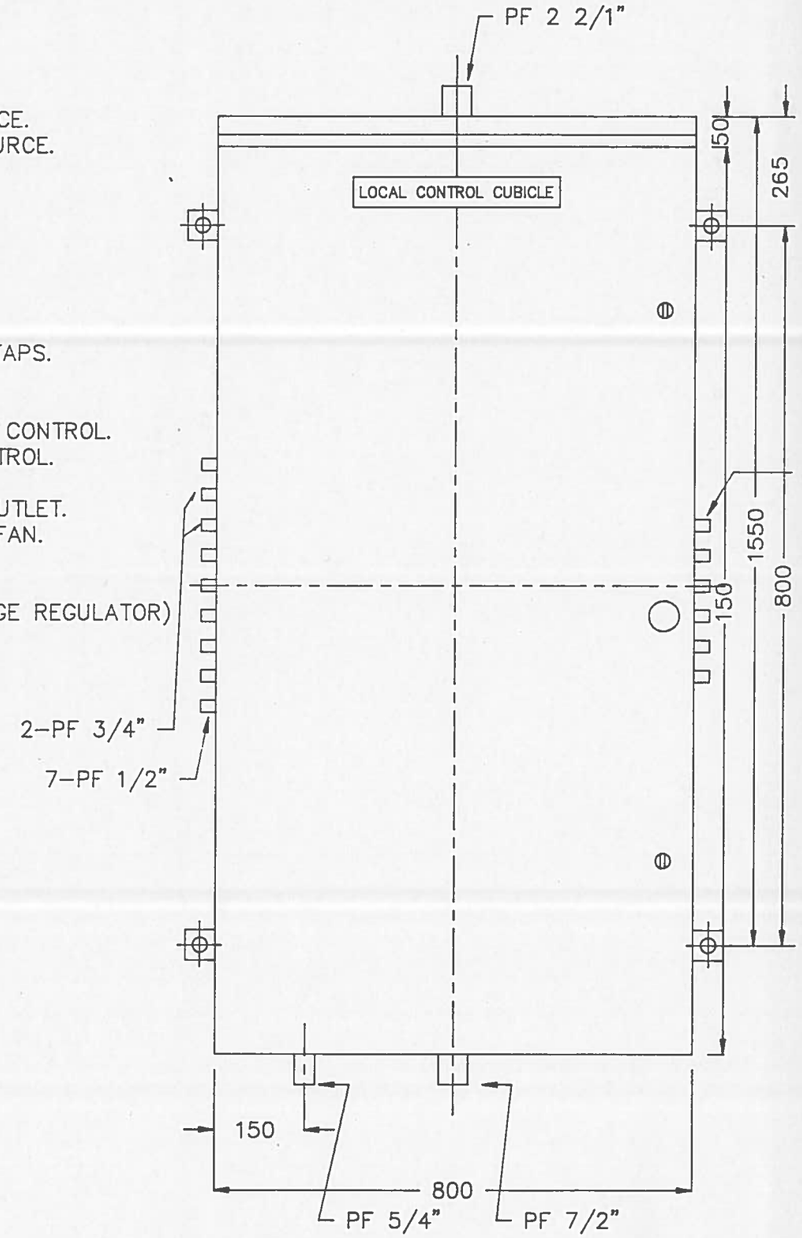
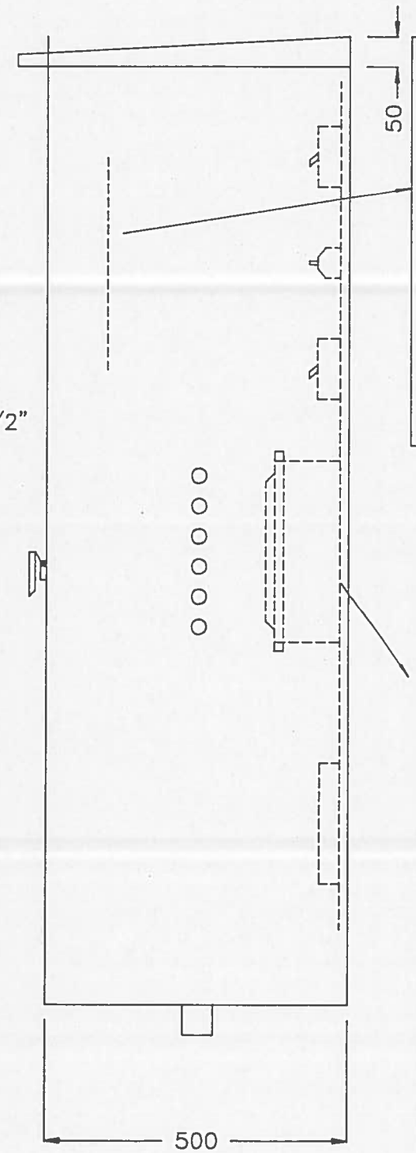
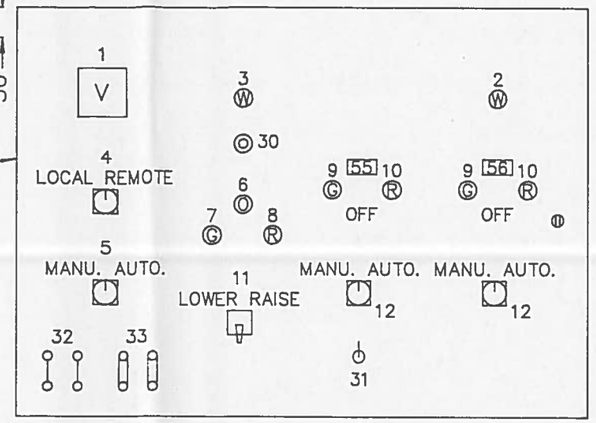
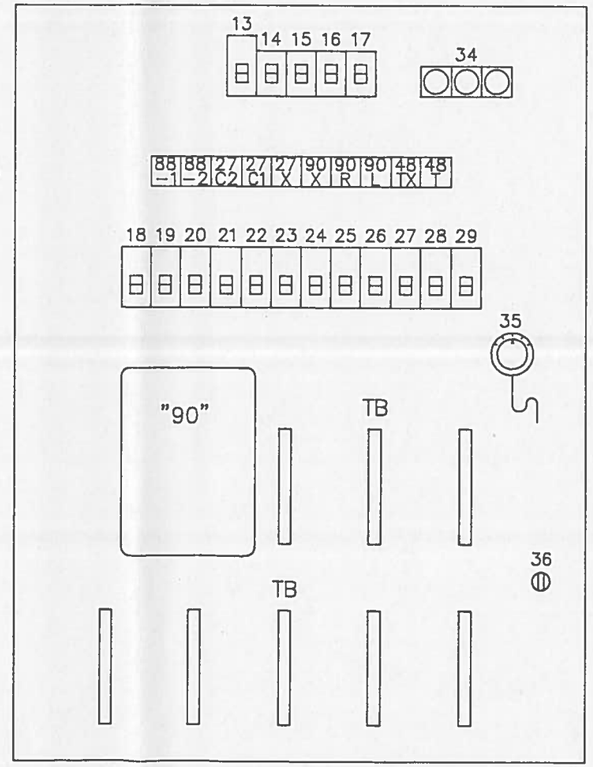
36. OUTLET.





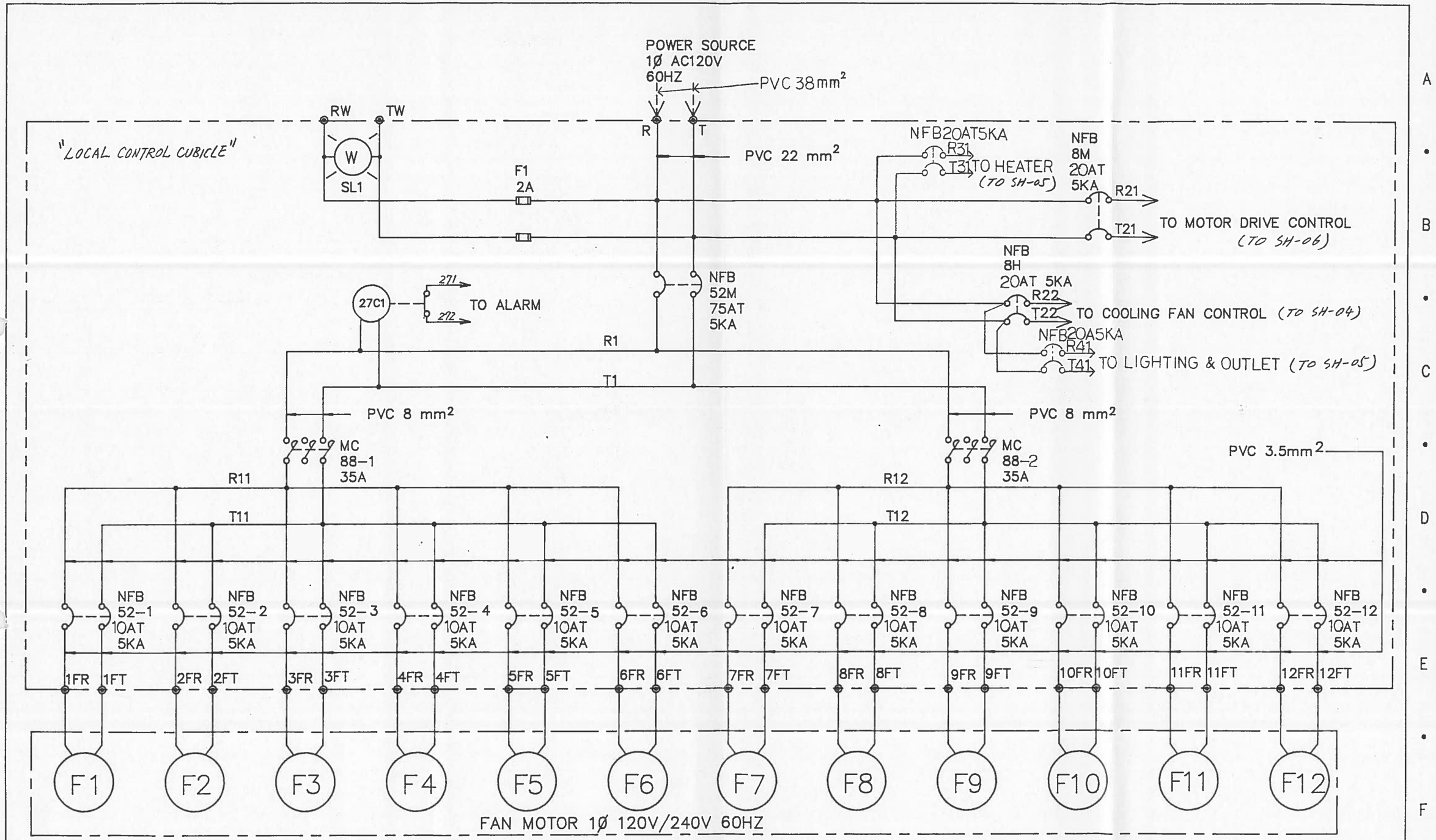




G.P.A.P.O.NO.B800-01137

REVISION				

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY	G.P.A 28MVA LOCAL CONTROL CUBICLE OUTLINE DIAGRAM
E.Z.Yeh		Arieton-Tsai	吳金玉	
Nov. 1, '88		oct-14-'88	78-03-17	478-02165-02
REGISTERED				



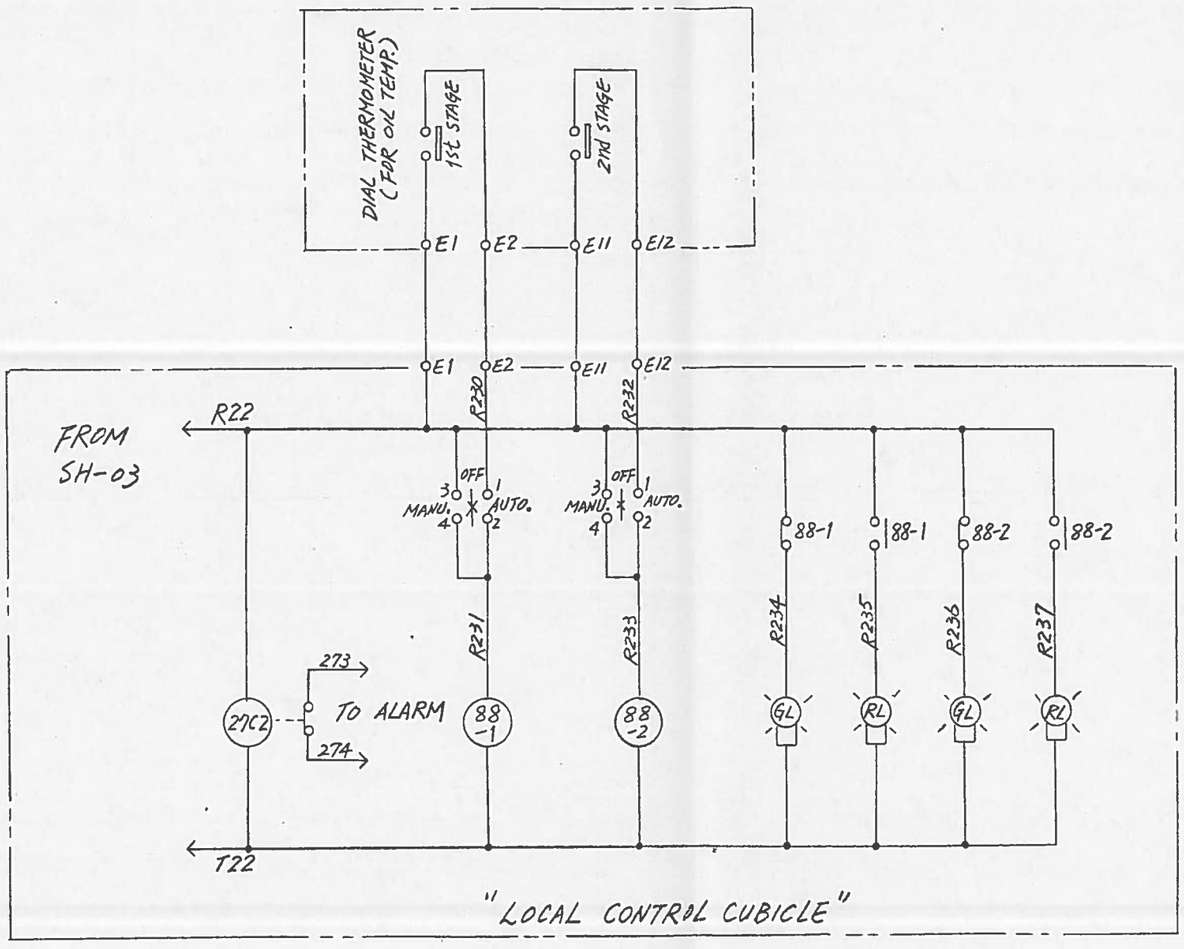
REVISION	

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY
E. Z. Ysh		AVICTOR-TSAI	Auto-cad
NOV-1-'88		OCT-14-'88	77-09-14
REGISTERED			

G.P.A 28MVA COOLING FAN
MAIN CIRCUIT

478-02165-03

G.P.A. P.O. NO. B800-01137



REVISION	

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY
C H LEE		AVICTOR	
MAY 13-'89	— —	Feb 27-'89	— —
REGISTERED			

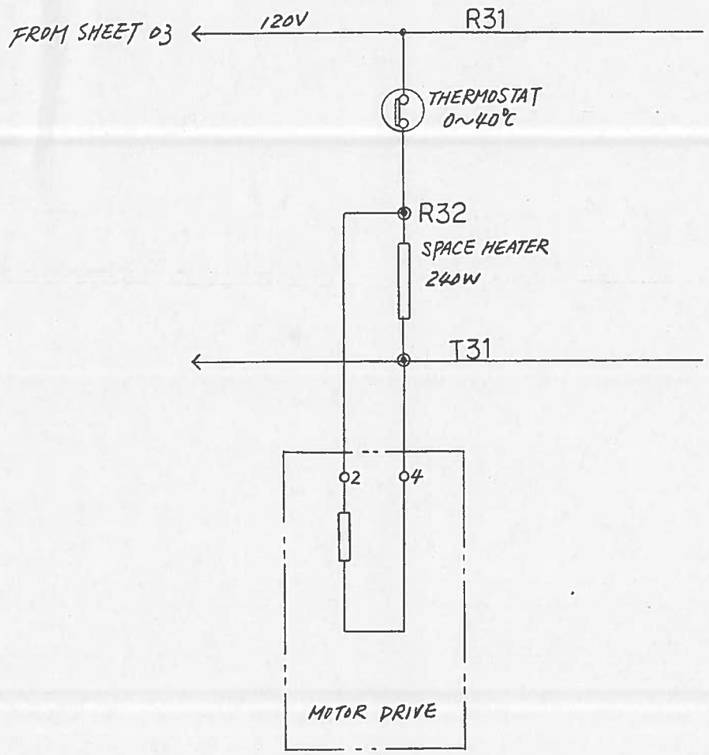
COOLING FAN CONTROL CIRCUIT

478-02165~04

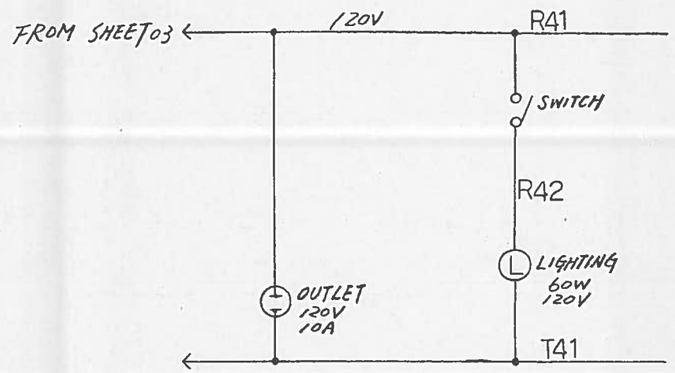
G.P.A. P.O. NO. B800-01137

TATUNG CO

HEARTING CIRCUIT



LIGHTING CIRCUIT



A • B • C • D • E • F •

REVISION	

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY	HEATING & LIGHTING CIRCUIT
E. Z. Yeh		AVICTOR-Tsai		
Nov 1-88	— —	OCT. 6-88	— —	478-02165~05
REGISTERED				

G.P.A. P.O. NO. B800-01137

SUPPLY PARTS ONLY FURNISH BY G.P.A.

"REMOTE CONTROL ROOM"

* ABOUT THE LTC ON AUTO. WE HAVE OTHER INSTRUCTION BOOK ATTACH FOR YOU.

AUTO MANU RAISE LOWER

SOURCE T S R

TR 3ø 34.5KV/13.8KV 28MVA

BCT 2000/5A 300/5

PT 3ø Y-Y 8400/120V

LOAD N T S R

C.T.T AUX-CT 5/0.2A

P.T.T

F 2A

LOCAL REMOTE AUTO MANU

"90"

90X 27X 48TX 90R 90L

RAISE-RAISE

TPI

RESET P.B

"LOCAL CONTROL CUBICLE"

FROM SH-03

FROM SH-05

SEQUENCE DIAGRAM /STEP

S37 S36 S35 S12 S11

8 REVOLUTIONS OF TAKE-OFF SHAFT/STEP

0~200 Ohm

C1	STARTING CATACITOR 18uF	R5	DAMPING RESISTOR 4 OHMS
C2	OPERATING CAPACITOR 30uF	S1-2	KEY FOR STEP BY STEP CONTROL
D1	IMPULS COUNTER	S3-4	KEY FOR STEP BY STEP CONTROL
E1	HEATING ELEMENT	S6	KEY FOR EMERGENCY STOP
H1	PROGRESS LAMP	S5-9	LIMIT SWITCH
K1-2	MOTOR CONTACTOR	S11-12	DIRECTION OF ROTATION SWITCH
K4	BRAKING CONTRCTOR	S18	MULTI-CONTACT DIAL SWITCH
K5	STEP BY STEP CONTACTOR	S35-36	CONTROL CONTACT
K7-8	AUXILIARY RELAY	S37	AUXILIARY CONTACT
K11	TIME DELAY RELAY	S40	SECURITY SWITCH
M1	DRIVING MOTOR	X10	TERMINAL STRIP
Q1	MOTOR PROTECTIVE SWITCH		
R1	RESISTANCE TELE-TARNSMITTER		

NO.1
MOTOR DRIVE MA-E/4(TU)

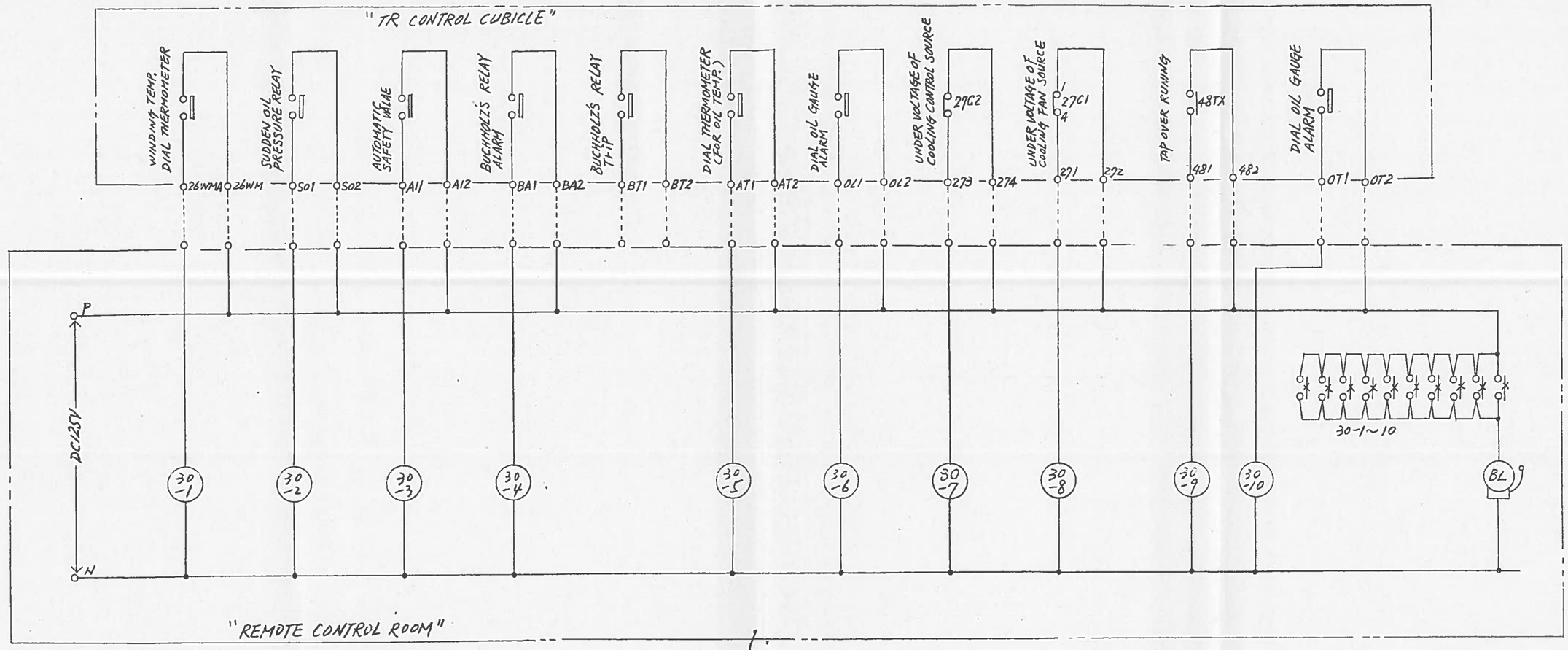
REVISION	
1	Revise Dec.-7-'88 Aviction.
2	
3	

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY
C.H. Lee		Aviction-Tsai	J-U-Wu
DEC-3-'88		OCT-14-'88	77-10-08
REGISTERED			

G.P.A 28MVA MOTOR DRIVE CONTROL CIRCUIT

478-02165-06

G.P.A. P.O. NO. B800-01137



SUPPLY PARTS ONLY FURNISH BY G.P.A.

REVISION		
	1	Revise Dec.-8-'88 Victor

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY
E. Z. Yeh		VICTOR-Tsai	
Nov 1 -'88	— —	Oct 14 -'88	— —
REGISTERED			

G. P. A 28MVA ALARM CIRCUIT

478-02165~07

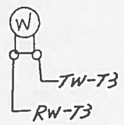
G.P.A. P.O. NO. B800-01137

TATUNG CO

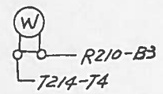
3 4 5 6 7 8 9

A B C D E F

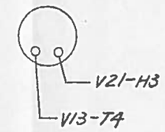
A1
PL 30Φ
AC120V/18V
60HZ



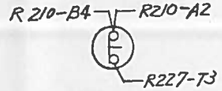
A2
PL 30Φ
AC120V/18V
60HZ



A3
VM 8400V/120V
60HZ

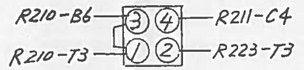


B3
PB 30Φ
1a 1b

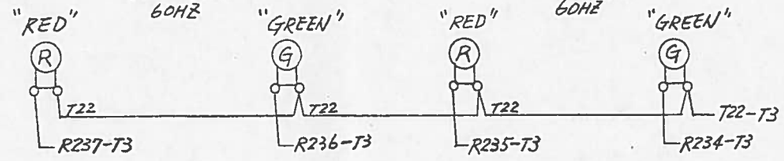


B5
PL 30Φ
AC120V/18V
60HZ

B7
COS
TS3-1A1B
REMO. LOCAL



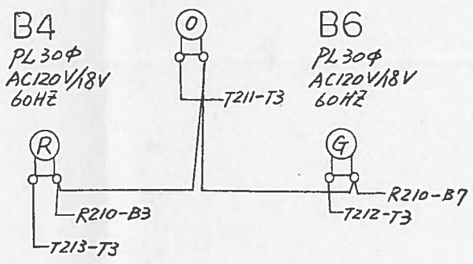
B1
PL 30ΦX2
AC120V/18V
60HZ



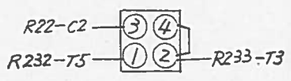
B2
PL 30ΦX2
AC120V/18V
60HZ

B4
PL 30Φ
AC120V/18V
60HZ

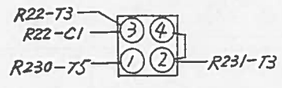
B6
PL 30Φ
AC120V/18V
60HZ



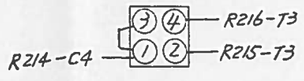
C1
COS
TS3-1A1B
AUTO. MANU.



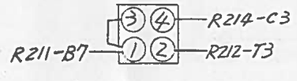
C2
COS
TS3-1A1B
AUTO. MANU.



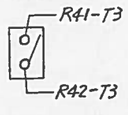
C3
CS TS3C-2
RAISE LOWER



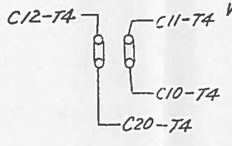
C4
COS
TS3-1A1B
AUTO. MANU.



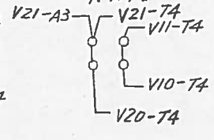
H1
SNAP SW.
AC250V 6A



H2
C.T.



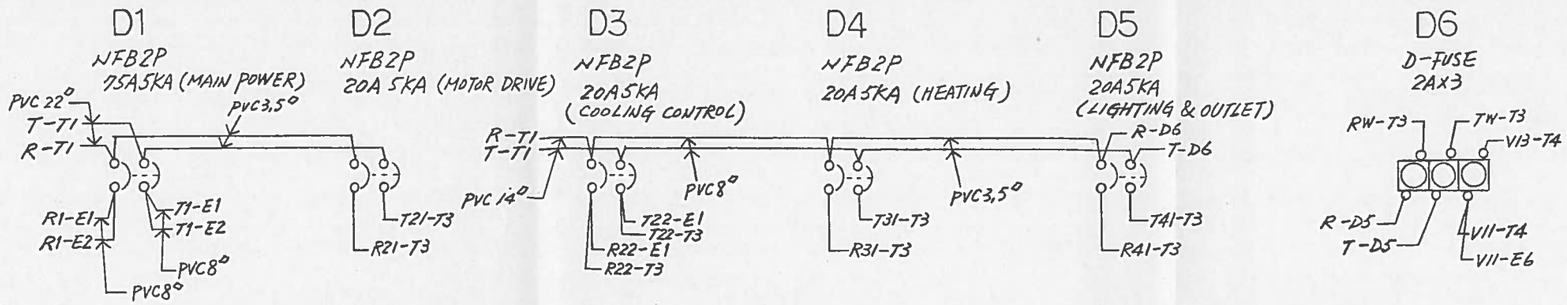
H3
P.T.T.

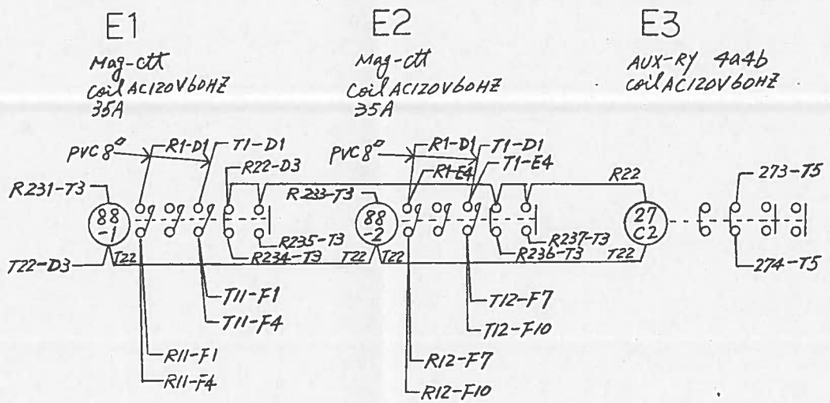


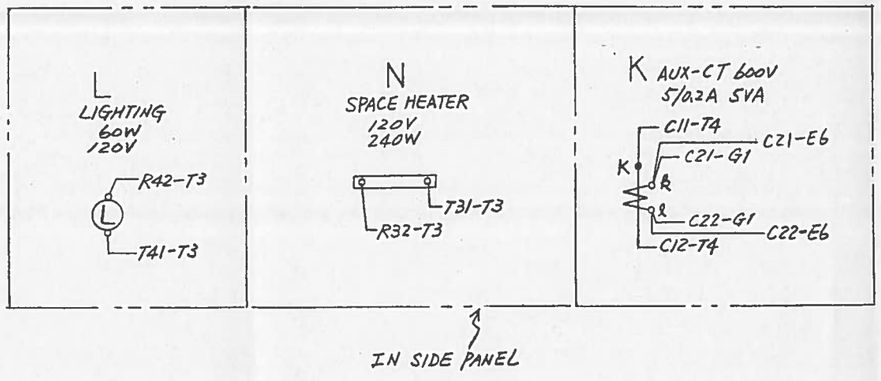
REVISION					

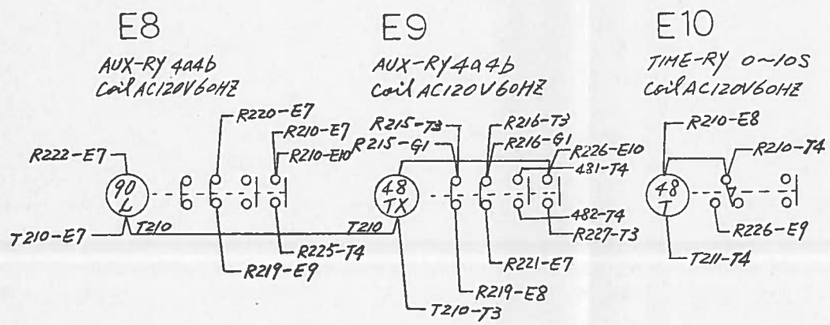
APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY	CONNECTION DIAGRAM "A"
C. H LEE		Stricter-Tsai		
MAY 17-'89	— —	MAY 2-'89	— —	478-02165-08
REGISTERED				

G.P.A. P.O. NO. B800-01137









REVISION	

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY	CONNECTION DIAGRAM "B"
C. H. CTT		Arieten Tsai		
MAR 13-'89	— —	MAR 2-'89	— —	478-02165~09
REGISTERED				

G.P.A. P.O. NO. B800-01137

TATUNG CO

F1 NFB2P 10A 5KA
F2 〃
F3 〃
F4 〃
F5 〃
F6 〃
F7 〃
F8 〃
F9 〃
F10 〃
F11 〃
F12 〃

R11-E1
T11-E1
1FT-T1
1FR-T1
2FT-T1
2FR-T1
3FT-T1
3FR-T1
R11-E1
T11-E1
4FT-T1
4FR-T1
5FT-T1
5FR-T1
6FT-T1
6FR-T1
R12-E2
T12-E2
7FT-T2
7FR-T2
8FT-T2
8FR-T2
9FT-T2
9FR-T2
R12-E2
T12-E2
10FT-T2
10FR-T2
11FT-T2
11FR-T2
12FT-T2
12FR-T2

G2
THERMOSTAT
0~40°C
R31-T3
R32-T3

G1 AVR 95~130V 0.2A
"90"
MK20
1 2 11 12 10 9 8 7 6 5 20 19 13 14 15 16 17 18 22 23 21
V12-E6
V22-E6
C22-K
C21-K
R213-E6
R215-E9
R216-E9
R210-E7
R217-E5

T1
TB12P30AX1
3P150AX1
1FR — 1FR-F1
1FT — 1FT-F1
2FR — 2FR-F2
2FT — 2FT-F2
3FR — 3FR-F3
3FT — 3FT-F3
4FR — 4FR-F4
4FT — 4FT-F4
5FR — 5FR-F5
5FT — 5FT-F5
6FR — 6FR-F6
6FT — 6FT-F6

T2
TB12P30A
7FR — 7FR-F7
7FT — 7FT-F7
8FR — 8FR-F8
8FT — 8FT-F8
9FR — 9FR-F9
9FT — 9FT-F9
10FR — 10FR-F10
10FT — 10FT-F10
11FR — 11FR-F11
11FT — 11FT-F11
12FR — 12FR-F12
12FT — 12FT-F12

R-D3
R-D1
R
T-D3
T-D1
T
PVC14°
PVC22°

T3
TB30P30AX1
R21-D2 — R21
T21-D2 — T21
R22-C2 — R22 — R22-T5, R22-D3
T22-B2 — T22 — T22-D3
R31-D4 — R31 — R31-G2
R32-G2 — R32 — R32-N
T31-D4 — T31 — T31-N
R41-H1 — R41 — R41-D5, R41-J
R42-H1 — R42 — R42-L, T41-J
T41-D5, RW-A1 — T41 — T41-L
RW-D6 — RW
TW-A1, TW-D6 — TW
R210-T4, R210-B7 — R210
R212-E6, R212-C4 — R212
R215-E9, R215-C3 — R215
R216-E9, R216-C3 — R216
R223-B7 — R223
TO CONTROL ROOM
R227-B3 — R227 — R227-E9
R231-C2 — R231 — R231-E1
R233-C1 — R233 — R233-E2
R234-B2 — R234 — R234-E1
R235-B2 — R235 — R235-E1
R236-B1 — R236 — R236-E2
R237-B1 — R237 — R237-E2
T210-T4, T210-E9 — T210
T211-T4, T211-B5 — T211
T212-T4, T212-B6 — T212
T213-B4, T213-T4 — T213
TO CONTROL ROOM

T4
TB12P30AX2
C10-H2 — C10 — C10-T7
C11-H2 — C11 — C11-K
C12-H2 — C12 — C12-K
C20-H2 — C20 — C20-T7
V10-H3 — V10
V11-H3, V11-D6 — V11
V13-D6 — V13 — V13-A3
V20-H3 — V20
V21-H3 — V21 — V21-E6
T214-A2 — 12
R210-E10, R210-T3 — 13
T210-T3 — 16
R225-E8 — 26
R224-E7 — 27
28
T211-E10 — 29
T211-T3 — 31
T212-T3 — 32
T213-T3 — 35
36
37
481-E9 — 481
482-E9 — 482
E
PVC5.5°
G.B. 3"x25

T5
TB12P30AX2
26WMA
26WM
SO1
SO2
A11
A12
BA1
BA2
BT1
BT2
AT1
AT2
R22-T3 — E1
R230-C2 — E2
E11
R232-C1 — E12
271-E4 — 271
272-E4 — 272
273-E3 — 273
274-E3 — 274
0L1
0L2
0T1
0T2

T6 12P30AX2
CT TB/WITH SHORT BAR
X1H1
X2H1
X3H1
X4H1
X5H1
X1H2
X2H2
X3H2
X4H2
X5H2
X1H3
X2H3
X3H3
X4H3
X5H3
X1X0
X2X0
X3X0
X4X0
X5X0
X1X11
X2X11
X3X11
X4X11

T7 〃
C10-T4 — X1X12
X2X12
X3X12
X4X12
C20-T4 — X5X12
X1X2
X2X2
X3X2
X4X2
X5X2
CT1
CT2
X1X31
X2X31
X3X31
X4X31
X5X31
X1X32
X2X32
X3X32
X4X32
X5X32
X5X11

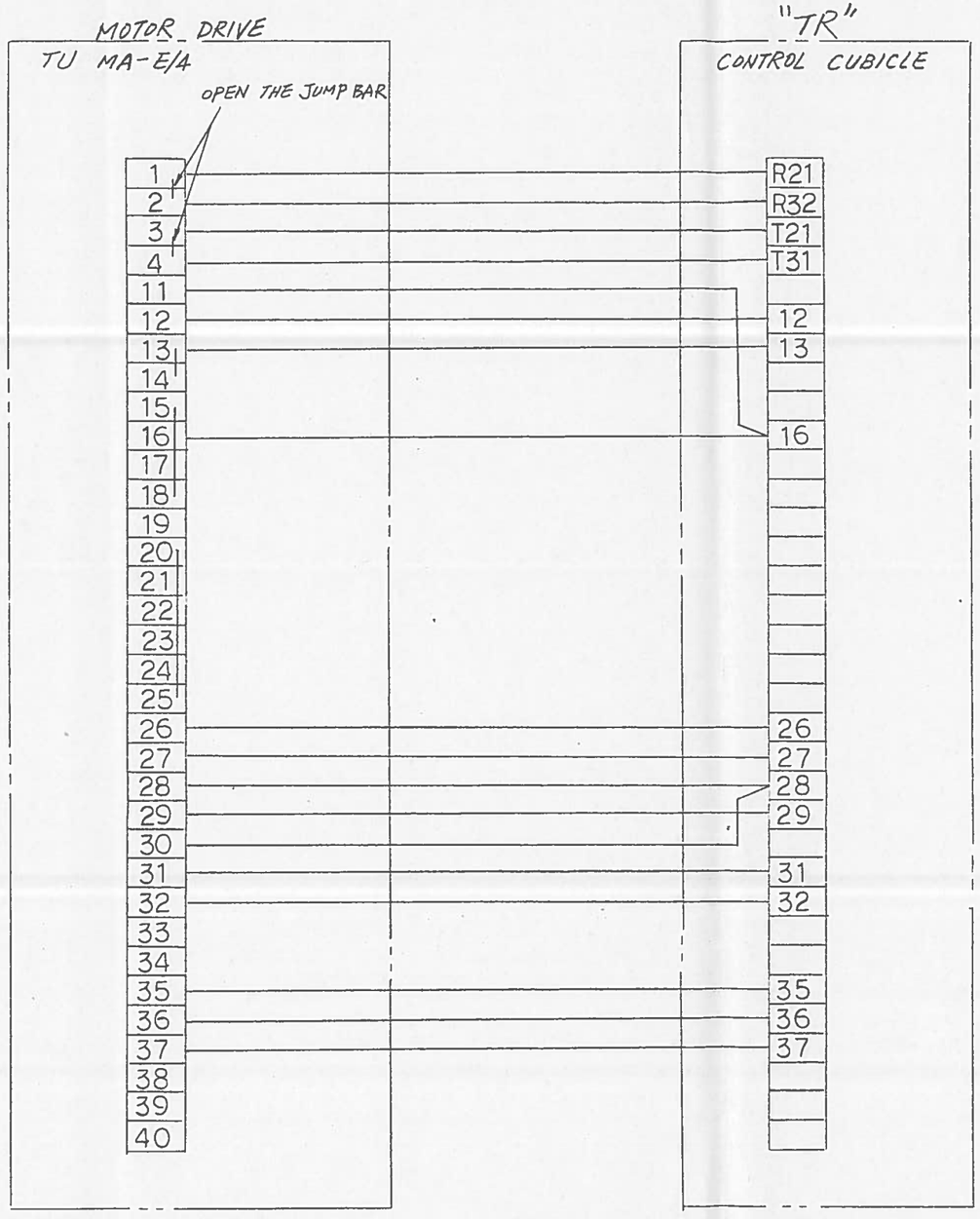
J
OUTLET
AC250V
10A
T41-T3
R41-T3

※ ALL WIRE ARE USE PVC3.5° EXCEPT LABEL ON ARROW.

REVISION	

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY	CONNECTION DIAGRAM "C"
C.H LEE		Avicter-Tsai		
Mar 13 — '89	— —	Mar — '89	— —	478-02165~10
REGISTERED				

G.P.A. P.O. NO. B800-01137



REVISION	

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY	CONNECTION DIAGRAM (FROM MOTOR DRIVE TO CUBICLE)
C.H LEE		Arieton-Tsai		
Mar 13 '89	— —	Mar 2 '89	— —	478-02165-11
REGISTERED				

G.P.A. P.O. NO. B800-01137

ITEM	DESCRIPTION
2	POWER SOURCE
3	CONTROL SOURCE
6	TAP RUNING
7	LOWER LIMIT
8	HIGHT LIMIT
9	FAN OFF
10	FAN ON
13	MAIN POWER
14	MOTOR DRIVE
15	FAN CONTROL
16	HEATING
17	LIGHTING & OUTLET
18	NO.1 FAN
19	NO.2 FAN
20	NO.3 FAN
21	NO.4 FAN
22	NO.5 FAN
23	NO.6 FAN
24	NO.7 FAN

25	NO.8 FAN
26	NO.9 FAN
27	NO.10 FAN
28	NO.11 FAN
29	NO.12 FAN
30	RESET
31	LIGHTING
32	P.T.T.
33	C.T.T.
34	D-FUSE
35	THERMOSTAT
36	OUTLET
37	88-1
38	88-2
39	27C1
40	27C2
41	27X
42	90X
43	90R
44	90L

45	48TX
46	48T
47	T1
48	T2
49	T3
50	T4
51	T5
52	T6
53	T7
54	90
55	FAN GROUP "1"
56	FAN GROUP "2"
57	
58	
59	
60	
61	
62	
63	
64	

REVISION	

APPROVED BY	CHECKED BY	DESIGNED BY	DRAWN BY
C-H CEE		Avictor-Tsai	
MAY 13-'89	— —	MAY 2-'89	— —
REGISTERED			

NAME PLATE FOR CONTROL PARTS

478-02165~12

G.P.A. P.O. NO. B800-01137

H1 X1H1 X2H1 X3H1 X4H1 X5H1
H2 X1H2 X2H2 X3H2 X4H2 X5H2
H3 X1H3 X2H3 X3H3 X4H3 X5H3
X0 X1X0 X2X0 X3X0 X4X0 X5X0
X1 X1X11 X2X11 X3X11 X4X11 X5X11 X1X12 X2X12 X3X12 X4X12 X5X12
X2 X1X2 X2X2 X3X2 X4X2 X5X2 CT
X3 X1X31 X2X31 X3X31 X4X31 X5X31 X1X32 X2X32 X3X32 X4X32 X5X32

DIAL THERMOMETER (FOR WINDING TEMP.)
ALARM: 26WMA 26WM
HEATING ELEMENT: MATCHING RESISTANCE — CT1 TO CT CT2

SUDDEN OIL PRESSURE RELAY: SO1 SO2

AUTOMATIC SAFETY VALVE: A11 A12

BUCHHOLZ'S RELAY
ALARM: BA1 BA2
TRIP: BT1 BT2

NO.1: 1FR 1FT
NO.7: 7FR 7FT
NO.2: 2FR 2FT
NO.8: 8FR 8FT
NO.3: 3FR 3FT
NO.9: 9FR 9FT
NO.4: 4FR 4FT
NO.10: 10FR 10FT
NO.5: 5FR 5FT
NO.11: 11FR 11FT
NO.6: 6FR 6FT
NO.12: 12FR 12FT

X1X11 X2X11 X3X11 X4X11 X5X11 X1X31 X2X31 X3X31 X4X31 X5X31 CT1 CT2
X1H1 X2H1 X3H1 X4H1 X5H1 X1H2 X2H2 X3H2 X4H2 X5H2 X1H3 X2H3
X3H3 X4H3 X5H3 X1X12 X2X12 X3X12 X4X12 X5X12 X1X2 X2X2 X3X2 X4X2
X5X2 X1X32 X2X32 X3X32 X4X32 X5X32 8FR 8FT 9FR 9FT 10FR 10FT
2FR 2FT 3FR 3FT 4FR 4FT 5FR 5FT 6FR 6FT 7FR 7FT
1FR 1FT 11FR 11FT 12FR 12FT BT1 BT2 BA1 BA2 A11 A12
SO1 SO2 AT1 AT2 E11 E12 E1 E2 26WMA 26WM R T
OL1 OL2 OT1 OT2 X1X0 X2X0 X3X0 X4X0 X5X0

DIAL THERMOMETER (FOR OIL TEMP.)
ALARM: AT1 AT2
START (1st STAGE): E1 E2
START (2nd STAGE): E11 E12

DIAL OIL GAUGE
TRIP (FOR LOWEST OIL): OT1 OT2
ALARM (FOR UNDER OIL): OL1 OL2

APPROVED BY	CHECKED BY
J.Y. Chen Aug. 25 '88	S.H. Shyu Aug. 25 '88
DESIGNED BY	DRAWN BY
	W.K. Lee Aug. 25, '88

SCHEMATIC DIAGRAM

TATUNG CO.
TAIPEI THE REPUBLIC OF CHINA

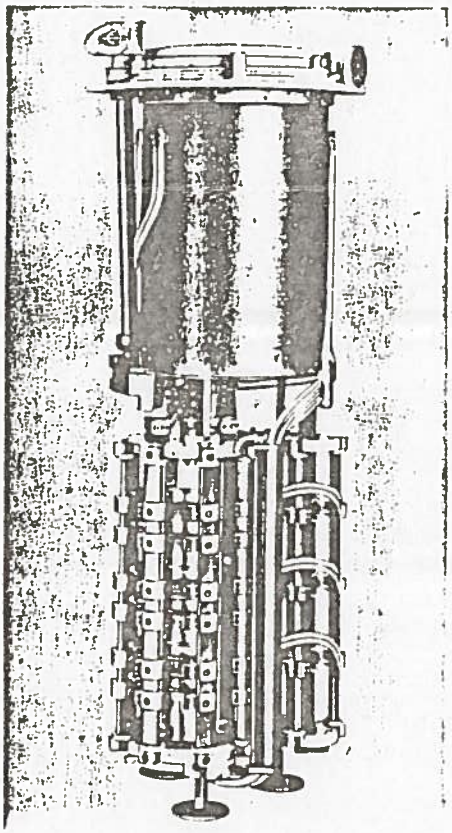
453-07348

REGISTERED

Trafo-Union

HR-64016-60-1

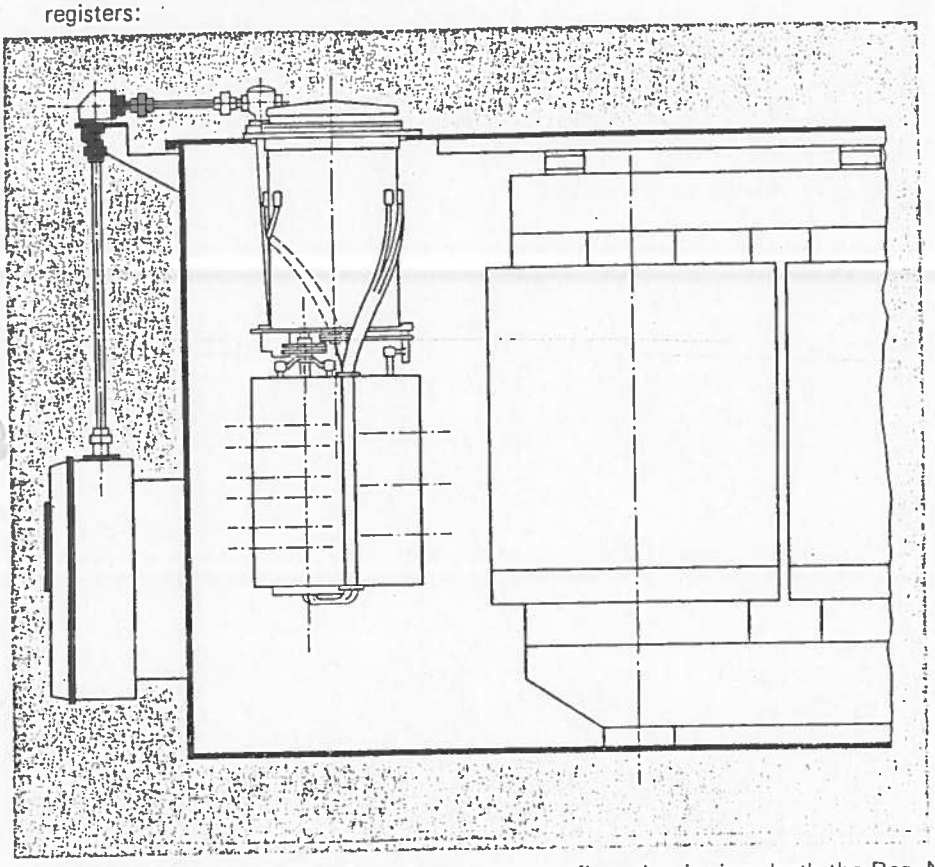
TU on-load tap-changers for transformers



1. Introduction

1.0 Structure of the manual

The manual is subdivided into 5 main registers:



Since we follow a policy of continous development and improvement of our tap-changers the data and information contained in this manual is only binding for offers and orders, when this is expressly stated by us. When such confirmation is given both the Reg.-No. and the Drawing-No. of the manual documentation must agree with our given confirmation.
If this is not so we shall be informed without delay.

1.1 Description of Trafo-Union on-load tap-changers

1.1.0 The Trafo-Union Basic Type Program

Trafo-Union on-load tap-changers are of the well-tried Jansen type. They comprise a tap selector with or without a change-over selector and a diverter switch of the high-speed transition resistor type oil-immersed in a pressure-tight insulating tank and therefore absolutly separated from the insulating liquid of the transformer, **Figs. 1 to 9, (Reg. a.09-a.12).**
The Trafo-Union Basic Type Program comprises four Basic Types I to IV, according to **Reg. a.20,** of which individual application ranges are listed in **Table 1.**

The range includes on-load tap-changers in neutral-point and single-phase versions for rated currents between 200 and > 3000 A, system voltages 10 to 420 kV and above. The new Trafo-Union Basic Types incorporate the experience gained from the production of more than 10,000 on-load tap-changers which are in service in transformers with power ratings up to more than 1000 MVA. Trafo-Union on-load tap-changers have given excellent service also under the most severe operating conditions in network transformers, generator transformers, furnace transformers, rectifier transformers and special transformers.

Application range \ Basic Type	I	II	III	IV
System voltage kV	10 – 150	10 – 220	10 – 420	10 – > 420
Transformer power in neutral point connection (MVA)	1 – ~ 35	10 – ~ 100	20 – ~800	30 – >1000
Transformer power in delta connection (MVA)	1 – ~ 60	10 – ~ 200	> 20	> 30

Table 1: Application range of Trafo-Union Basic Type on-load tap-changers.

Each Basic Type of on-load tap-changer is available in several versions. A building-block system allows the many different versions to be assembled by use of equal components. For each Basic Type of selector this offers many possibilities in terms of the number of steps, characteristic connections, number of selector levels, test voltages and mounting arrangements.

According to **Reg. a.21,** for example, with the Selector Basic Type III there are in all approximately 1000 available versions. Despite the plurality of versions, economic production and short delivery times are made possible by the building-block system.
All tap-changers in the Basic-Range comply with the requirements of IEC 214, VDE 0531, NEMA, ANSI and other national rules. They also satisfy the overload conditions specified in IEC 354 and VDE 0536. The short-circuit current considerably exceeds the requirements of IEC 214 and VDE 0531 partially.

1.1.1 The Trafo-Union combination system

The Trafo-Union Basic Type Program is also designed to permit modules of different Basic Types to be combined with each other. According to the interconnecting lines in **Reg. a.20,** for example, it is possible for the Basic Selector III to be combinedwith either diverter switch tank II or IV as well as III.
This further allows all diverter switches I to VII which can be used in these three diverter switch tanks to be combined optionally with the Basic Selector III. The combination system has considerable economic and technical benefits. According to the particular requirements it permits the cheapest modules to be used to build up a suitable tap-changer.
Moreover, in the case of transformers where the number of on-load tap-changer operations is exceptionally high it is possible to use a diverter switch of a higher rated current in order to increase the electrical life without also having to use a selector of higher rated current.

1.1.2 Survey of types

Each Basic Type can be used for windings, which have star or delta connection, three-phase transformers, single-phase transformers and autotransformers, see **Reg. a.22.**

In the neutral point connection — on-load tap-changer Type CRN — all three phases are combined in one tap-changer column. For the delta connection the exceptionally economic and compact on-load tap-changer Type XRS with two tap-changer columns is available or the on-load tap-changer Type 3 x ARS with three columns. A survey of the complete Type Program is given in **Reg. a.23.** The **Reg. a.70 to a.76** show the most important characteristic connections practicable.

1.1.3 Special features of Trafo-Union on-load tap-changers

The Trafo-Union on-load tap-changers are of compactness, simple installation and, as a result of their simple mode of operation, high reliability and long life. Tap-changer Types B I, II and III can be fitted directly into the transformer as supplied by the factory, i.e. without any preparatory work. For special cases the Basic Type III requires some minor installation work at the change-over selector to be done. All on-load tap-changers are suitable for vapour-phase drying. See the mounting instructions.

All selector contacts have a solid silver facing of a thickness adequate for several million switching operations. The mating contacts are made of copper or a high-strength copper alloy. In addition to long mechanical life this pairing of materials offers the advantage of only a very slight increase in contact resistance due to the formation of foreign layers of the surface during many years of service, even under very unfavorable conditions in this respect, namely very few switching operations. This feature gives a high level of security against contact failure due to the formation of oil carbon.

The lightning impulse withstand voltages of the individual insulating distances in the tap selector, change-over selector and diverter switch are carefully matched to each other so that, while maintaining minimum size, the tap-changers can be used for the many different types of winding and connections of the tapping winding. See **chapter 2.3 and 2.4.**

The diverter switches are of the high-speed transition resistor type employing the well-tried flag cycle system. Generous contact surfaces of burn-resistant, sintered tungsten-copper combined with accurate parallel location ensure a long electrical life for the diverter switch contacts. Depending on the rated current and type of diverter switch, a contact life of more than 500,000 on-load tap-change operations, when carrying rated current continuously, can be achieved. Long creepage paths inside the diverter switch and between the diverter switch and earth potential ensure high dielectric strength even after many switching operations.

The cover for each diverter switch tank incorporates a large-area pressure relief device which protects the tank at disturbances involving a severe rise in pressure. The diverter switch with transition resistor can be easily lifted out for revisions after removing the top cover on the tap-changer.

1.1.4 Special versions

Tap-changers with high numbers of steps:
The B II on-load tap-changers can be supplied in special versions with a multiple change-over selector suitable for up to 125 steps. Further details are available upon request.

Tap-changers of short length:
On-load tap-changers of less than normal overall length can sometimes be required for large power transformers. For such applications there are special versions having two selectors side by side, see **Reg. a.29 and Fig. 7.** Further details are available upon request.

1.2 The subassembly groups of Trafo-Union on-load tap-changers

1.2.0 Survey

Reg. a.24 and a.25 show the principal subassembly groups and individual parts of the Trafo-Union on-load tap--changers.

All types can be delivered either for cover mounting, as in **Reg. a.24,** or for fork mounting, as in **Reg. a.25.**

The cover-mounted version is used, when the core and coil assembly of the transformer is attached to the cover and both are inserted into the transformer tank together when the core and coil assembly is ready. Fork-mounting tap--changers are better, on the other hand, for dome-type tanks or when the transformer cover is not fitted until the core and coil assembly has been insertet into the transformer tank.

The numbers in brackets in the text are the subassembly group or individual parts (according to **Reg. a.24 or a.25).**

1.2.1 Diverter switch with transition resistor — subassembly group (300)

The switching cycle of a Trafo-Union diverter switch is shown in **Reg. a.26. Reg. a.27** shows a relevant switching oscillogram. The diverter switches are of the high-speed transition resistor type. The motor-drive mechanism compresses a set of energy storing springs in the diverter switch, which perform the switching operation independently of the motor-drive mechanism. The transition resistors are also designed in excess of IEC 214 rules to permit occasional switching operations at three times rated current.

On the basis of extensive testing and the evaluation of all available operating experience, Trafo-Union diverter switches were further developed so that the new program offers a mechanical life between approximately 400,000 and 1 million on-load tap-change operations, depending on the type of diverter switch.

1.2.2 Tap-changer top section and diverter switch tank — subassembly group (100) and (200)

The diverter switch tank provides absolute separation of the diverter switch oil, which becomes contaminated with carbon particles due to arcing, from the insulating liquid of the transformer

The growing emphasis on gas analysis for the detection of faults in transformers means that a reliable seal between the transformer insulating liquid and the diverter switch oil is becoming more and more important. In the new types, therefore, double sealings were adopted for all joints on the diverter switch tank. They are designed so that either one of the sealings can be renewed after opening up the top of the tap--changer the second sealing can either be supplemented (in the case of tap--changer types B I and II) or renewed (B III and IV) without first lowering the level of the insulating liquid in the transformer tank.

Many tests have shown, and practice confirms, that even the best sealing materials available at present age to a certain extent under the extreme conditions found in transformer tanks — high temperature and the effect of mineral oil. When leaks occur after some years in service the new system allows sealings to be supplemented respectively renewed without difficulty.

The design of the input bearing (501 or 520) for the drive shaft is such that, when opening up the top of the tap--changer for revision, ets., the shafting between the motor-drive mechanism and the tap-changer does not have to be disturbed — therefore there is no danger of inadvertently coupling up wrongly afterwards. Revisions are simplified as a result; see also the mounting instructions. All diverter switch tanks are pressure tested by the factory to a pressure of 0.7 bar.

The top section of the tap-changer incorporates connecting flanges for the pipes to the conservator (116) and for an oil drain valve (117).
In the case of diverter switch tanks Basic Type I to IV — except the fork mounting version of Basic Type II — there is an extra flange (118) through which the space between the diverter switch tank and the transformer tank top can be vented.

If a pipe is taken from this flange to the Buchholz relay for the transformer tank, any gases formed as a result of faults in the transformer and possibly collecting under neath the cover flange of the tap--changer will be led to the transformer Buchholz relay, see **Reg. 1.06, 1.07, 1.13 and 1.14** and the mounting instructions.

The surge pressure protective device (101) which is always incorporated in the top section of the tap-changers comprises a large-area diaphragm (106) which bulges outwards, when the internal pressure exceeds the maximum permissible value and first lifts the rupturing knife (104) causing a contact to be operated. This contact responds only a few milliseconds after the maximum permissible pressure has been exceeded and trips the transformer circuit-breaker. Thus, the device permits a rapid tripping of the transformer in the event of a fault inside the diverter switch tank. For further details see the descriptions "Surge pressure protective device for on-load tap-changer."

1.2.3 Tap selector and change-over selector — subassembly group (400)

The pairing of copper and solid silver for the selector contacts show excellent results during many years of service with numerous Trafo-Union tap-changers.
With the modern Trafo-Union designs a very high level of reliability and long life are still obtained under extreme operating conditions, i.e. as unusually high as unusually low numbers of switching operations.

The Basic Selectors I and II are practicable for 4 to ± 17 steps and III and IV for 4 to ± 19 steps. The most important connections practicable are shown in **Reg. a.22, a.70 to a.76.**

The change-over selector for the Basic Selectors III and IV is practicable in five different versions for each, see **Reg. a.28.** The version with damping and/or control resistors — versions C to E — shall be chosen if there is the possibility of heavy discharges due to capacitive voltage displacement on the fine tapping winding when the change--over selector contact is open. In the case of B II the D version can also be used by fitting additional contacts under the change-over selector. These various possibilities cover almost all conditions encountered in practice.

The damping resistors will be always delivered if change-over selectors fitted with damping contacts — version C and E according to **Reg. a.28.**
If control resistors are necessary on the change-over selector it is advisable to also obtain these from Trafo-Union.

When deciding whether or not damping resistor or control resistor contacts are necessary on the change-over selector remember that we are always available for consultation.

1.2.4 Accessories

Customers ordering their first tap--changer with cover mounting are delivered with a marking-out template for the thread bolts (112) for securing the cover flange on the transformer tank top immediately the order is received. Every tap-changer is also supplied with a socket spanner, **Reg. 7.01,** for tightening/releasing the diverter switch fixing bolts during revision work. A lifting device for the diverter switch is included with the Basic Types III and IV.

If the lightning impulse voltage stresses III, **Reg. a.61,** exceed the permissible values given in the data sheet, devices for limiting these overvoltages can be incorporated in the tap-changers. Voltage dependant resistors with spark gaps connected in series are normally used for this purpose (702). They are mounted directly on the diverter switch in the diverter switch tank and therefore can be checked, when the diverter switch is being inspected. They involve no extra overall length, i.e. dimensions e and g, **Reg. 0.01 to 0.89,** remain the same when this protection is fitted.

If required, however, voltage dependant resistors without spark gaps can also be provided (701). Again they will be normally fitted in the diverter switch tank if the step voltages are low. Higher step voltages necessitate an elongation of the diverter switch tank (dimension g) to accommodate the voltage dependant resistors. In this case we recommend fitting to the selector. In view of the generous safety factor incorporated in the sizing of the voltage dependant resistors it is possible to recommend this often applied and proven solution without restriction. The overall length of the tap-changer is increased to dimension d, **Reg. 0.01 to 0.89.**

The following are also available to order:

Protective relay for diverter switch (703), **Reg. 7.03.**

This is fitted in the connecting line between the top section of the tap-changer and the conservator. It responds in excess of a predetermined value of velocity of flow and trips the circuit-breaker to isolate the transformer from the network.

Locking gear (705)

As additional safety precaution against uncorrect coupling of the motor-drive mechanism and the on-load tap-changer e. g. after the shipment of transformer, it is possible to build on a locking gear (705) at each input bearing (501, 520) (Reg. 5.50, 5.51). Function see: "Mounting instructions for on-load tap-changers".

Oil-purifying apparatus:
It is connected to flanges (116) and (117) on the top section of the tap--changer. It is automatic in operation.

1.2.5 Motor-drive mechanism — subassembly group (600)

There are two types of motor-drive mechanism available — MA-E and MA-E/2.

They comprise the drive motor and gearbox, electrical and mechanical end stops, electrical control system and position indicating device. The motor size is selected by Trafo-Union according to the torque of the tap-changer involved. The running time of the motor-drive mechanism is normally 5 s per step.
For the selector types B I and B II a running time of 2.5 s per step can also be arranged, if required. Suitable motors for three-phase a.c., single-phase a.c. or d.c. at various voltages can be supplied. Also, numerous special circuit arrangements and additional devices can be incorporated, if required.

The Type MA-E motor-drive mechanism offers more facilities for the fitting of extra devices than the Type MA-E/2 mechanism due to its larger size. Further details are given in the separate operation instruction of motor-drive mechanisms.

2. Technical data for Basic Type I on-load tap-changers

1.2.6 Possible arrangements of the tap-changers and shaftings – subassembly group (500)

There are alternative shafting arrangements available for placing the input bearing on the top section of the tap-changer on the side of the transformer tank, as shown in **Reg. a.24 and a.25.** The shafting systems are built up from modules which permit a large number of different arrangements, see chapter 3.5.

Each input bearing (501 or 520) incorporates a position indicator which ensures that the motor-drive mechanism is always coupled up to the tap-changer in the correct position so that the drive mechanism is properly lined up with the tap-changer. This eliminates the possibility of damage due to coupling-up incorrectly.

1.2.7 Type designations

The type number key for Trafo-Union on load tap-changers is explained in **Reg. a.32.** The **Reg. a.30 and a.31** give the type designations of the diverter switches and selectors available for the Basic Program on-load tap-changers.

1.3 Thyristor tap-changers

A thyristor tap-changer suitable for the abnormally high number of switching operations encountered specifically on electric locomotives is available and was used in large numbers for many years. Further details are available on request.

2.0 Survey

Reg. a.40 contains the essential technical data.

2.1. Diverter switch – subassembly group (300)

The technical data on the diverter switches are given in **Reg. a.41 to a.45.**

Diverter switch types 211, 411, 611. Load characteristic curves **Reg. a.41.** Contact life, **Reg. a.44.**

With single-phase diverter switches the permissible step power can be increased by dividing the winding into two or three parallel branches, see **Reg. a.41.** However, a necessary precondition for this is adequate stray inductance between the parallel winding branches. Further details are available upon request.

The curves of contact life, **Reg. a.44,** are valid for a constant average load current of the diverter switch. If the load fluctuates severely or part load of transformer is carried continuously the contact life will be much greater than indicated in **Reg. a.44.**
For Basic Type I the lightning impulse withstand voltage between selected and preselected tappings in the diverter switch (insulating distance III, **Reg. a.61**) is 80 $k\hat{V}$ with a full wave 1,2/50 µs, as shown in **Reg. a.43.** The actual stresses which occur at this point in the transformer, however, are considerably shorter and usually correspond approximately to a wave 1/5 µs. With this shorter time of stressing the lightning impulse withstand voltage increases to 110 $k\hat{V}$. If the stresses occurring at this point in the transformer are higher than the given withstand voltages, voltge dependant resistors will be fitted for voltage limiting in the tap-changer, see **chapter 1.2.4.**

2.2 Diverter switch tank – subassembly group (200)

For technical data, see **Reg. a.50 and a.51.**

2.3 Tap selector and change-over selector – subassembly group (400)

For technical data, see **Reg. a.52, a. 62 and a.63.**

For Basic Type I the lightning impulse withstand voltage between selected and preselected tappings in the selector (insulating distance III, **Reg. a.61**) is 130 kV with a full wave 1,2/50 µs, as shown in **Reg. a.52, a.62 and a.63.** The actual stresses which occur at this point in the transformer, however, are considerably shorter and usually correspond approximately to a wave 1/5 µs. With this shorter time of stressing the lightning impulse withstand voltage increases 185 $k\hat{V}$ in the case of oil-immersed transformers and to 150 $k\hat{V}$ with ascarel transformers. If the stresses occurring at this point in the transformer are higher than the given withstand voltages, voltage dependant resistors will be fitted for voltage limiting in the tap-changer, see **chapter 1.2.4.**

2.4 Connections

The **Reg. a.70 and a.71** show the principal connections and arrangements of the tapping windings of the transformer which can be fitted with Basic Type on-load tap-changers. All connections shown can use the Basic I selectors except in those cases where a two way change-over selector is needed.

Each of these connections can have different numbers of steps according to the characteristic connections shown in **Reg. a.72 to a.76.**

With the 5 to 9 selector rods practicable with Basic Selectors I and II all numbers of steps between 8 an 17 with no dead steps (positions of equal voltage) can be designed for reversing connection and also coarse/fine. Furthermore, 18/22/26/30/34 steps with no dead steps and no blocked up positions are possible.

An example for a connection with dead steps see **Reg. a.79.**

The number of rods of the relevant selector is indicated by the first two figures of the characteristic connections number in **Reg. a.72 to a.76,** e. g. 0604 = 6 selector rods, 1004 = 10 selector rods.

From the point of view of price characteristic connections with a smaller number of rods are cheaper. Similarly, it must be remembered that the lightning impulse withstand voltage in the tap selector falls, when the number of rods exceeds 7. In such cases it can be better to choose a connection with a higher number of steps but a lower number of rods and to block up the surplus positions in the range with the smallest number of turns, if necessary, e.g. to select characteristic connection 0511 instead of 0905 and block up tap 5. Despite a greater number of steps on the tapping winding this solution does not necessitate a greater total number of turns for the transformer windings (main winding and tapping winding).

More unfavourable lightning impulse voltage stresses between adjacent contacts in the tap selector can cause a reduction in the permissible lightning impulse withstand voltages for insulating distances IVa and IVb by the factors K according to **Reg. a.60** at some connections compared with the values given in **Reg. a.62, a.63.**

The connection diagrams in **Reg. 4.20 to 4.24** show the position of the contacts and the run of the factory-fitted internal conductor connections on the selector for the most important characteristic connections and numbers of steps.
Connection diagrams for further characteristic connections available upon request.

2.5 Weights, oil contents

The appropriate data are given in **Reg. a.90 to a.92.**

3. Dimension drawings and tap-changer detail drawings

3.01 Dimension drawings of normal types – subassembly group (000)

On-load tap-changers for cover mounting, **Reg. 0.01 to 0.04.**

In these dimension drawings the input bearing and vertical insulating shaft are shown for the above-cover shafting arrangement. In addition, the position of the pivot (507) of the selector gearing is shown dotted for the horizontal insulating shaft arrangement, which is available to special order.

On-load tap-changers for fork mounting, **Reg. 0.05 to 0.08**

In this version the insulating shaft is normally horizontal with the coupling point at the pivot of the selector gearing (507). As a special order a vertical insulating shaft (521) is also available with the input bearing (501) on the transformer cover (shown dotted).

The position of the insulating rods in the tap selector and change-over selector is shown in **Reg. 0.90.** The position of the connecting points of the contacts for the selector conductors are shown in the connection diagrams, **Reg. 4.20 to 4.24.**

3.03 Dimension drawings, combination types – subassembly group (000)

The following combination is possible with Basic-Selector I.

Combination Basic Selector I with diverter switch and diverter switch tank Basic Type II.

This combination will be used if the step power of the Basic I diverter switches is inadequate, if the lightning impulse withstand voltage in the diverter switches between selected and preselected tapping is indequate or if extra long electrical life of the diverter switch contacts is required for transformers involving an exceptionally high number of switching operations. The dimension drawings of Basic Selector I are applicable for the selector and selector details and the dimension drawings from the Basic Type II manual for the diverter switch tank, tap-changer top section and shafting.
Reg. 0.50 gives an example for the combination of the neutral-point version Basic Selector I with the Basic Type II diverter switch and diverter switch tank for cover mounting. **Reg. 0.55** shows the same combination but for fork mounting.
The essential technical data contain **Reg. a.47.**

3.1 Tap-changer top-section – subassembly group (100)

For details, see **Reg. 1.01 to 1.20.**

The on-load tap-changer top section (100) on the fork-mounted version can be rotated 20 times by 18° in relation to the selector (400), according to the thread bolts circle. Additional the surge pressure protective device (101) can be rotated 18 times by 20° in relation to the top flange (103) according to the pitch circle. By that it's possible the flanges (116) and (117) to displace, if necessary. 18 times 20° rotation of the surge pressure protective device is possible in the case of the cover-mounted version, also.

In the case of tap-changers for fork mounting a tolerance of ± 12 mm is allowed between the axes of the diverter switch tank and the transformer cover aperture.

See **Reg. 1.06, 1.07, 1.13 and 1.14** and the mounting instructions for on-load tap-changers for details of the pipework to the top section of the tap-changers.

3.2 Diverter switch tank — subassembly group (200)

The diverter switch tank for cover mounting is shown in **Reg. 2.01, 2.02, 2.20** and for fork mounting in **Reg. 2.10, 2.11, 2.20.**

3.3 Diverter switch with transition resistor — subassembly group (300)

Reg. 3.01 contains the lifting-out dimensions for the diverter switch.

3.4 Selector details and connection diagrams — subassembly group (400)

Details of the selector are shown in **Reg. 4.01 to 4.04.**
The connection diagrams in **Reg. 4.20 to 4.24** show the positions of the contacts and fixed connecting conductors on the tap selector and change-over selector for the most important characteristic connections.

3.5 Possible arrangements of the tap--changers and shaftings — subassembly group (500)

The Trafo-Union Basic Type Program offers a variety of possibilities in respect of arrangement and shafting system. A survey is given in **Reg. 5.01.**

The various arrangements with single--pole, two-pole and three-pole on-load tap-changers, vertical and horizontal insulating shaft, are shown in **Reg. 5.03 to 5.23.**

The various parts of the different versions, such as insulating shaft, input bearing, worm gear, etc., can be easily found in the table of **Reg. 5.02.**

It must be remembered that with a vertical insulating shaft the possible arrangements for cover-mounted tap--changers differ from those for fork--mounted tap-changers, see **Reg. 5.03 and 5.06,** for example. In contrast, the possible arrangements with a horizontal insulating shaft are identical for cover-mounted and fork-mounted tap--changers, see **Reg. 5.05, 5.12, 5.13, 5.22 and 5.23.**

For an external horizontal drive shaft (505) above the transformer cover versions 1 to 3 according to **Reg. 5.35** are available depending on the required lenght of the shafts and the difference in height between the two pivots. The necessary shaft lenghts, and also the design, are decided by Trafo-Union from the distance "a" between the bevel gear and the input bearing and, in the case of multi-pole tap-changers, from the distance "c", **Reg. 5.03 to 5.23.**

For an external vertical drive shaft above the motor-drive mechanism there is a choice of arrangements according to **Reg. 5.40 to 5.42.** Again the necessary shaft lenghts etc. are decided by Trafo-Union on the basis of dimension "b".

Which design is chosen depends on dimension "b" from the centre of the hand crank of the motor-drive mechanism to the horizontal axis of the bevel gear or input bearing and on any horizontal displacement "v" between the pivots of the motor-drive mechanism and the bevel gear or input bearing. If the cover of the transformer is insulated from the tank itself, or the motor--drive mechanism must be insulated from the transformer, an insulating section can be incorporated in the vertical drive shaft — version 4, **Reg. 5.40 to 5.42.** In addition to the shafting arrangements shown it is also possible to provide numerous special designs.

Note:
With all two-pole and three-pole tap--changer arrangements the motor-drive mechanism can be mounted either "left" or "right", state which is required when ordering.

3.6 Motor-drive mechanism — subassembly group (600)

Reg. 6.01 to 6.99 contain technical data, the principal dimensions of motor--drive mechanisms MA-E and MA-E/2 and a standard circuit diagram.

The motor-drive mechanisms are available in a plurality of special circuit diagrams and additional devices. Further details are given in the operation instruction on motor-drive mechanisms.

3.7 Accessories: Voltage dependant resistor, protective relay — subassembly group (700)

Reg. 7.01: Socket spanner for removing the diverter switch
Reg. 7.03: Protective relay (703) for diverter switch
Reg. 7.04: Voltage dependant resistor (without spark gap) for mounting below the tap selector.

3.8 Control room devices — subassembly group (800)

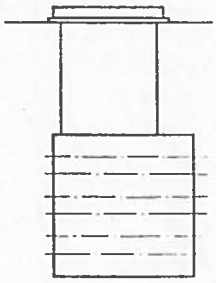
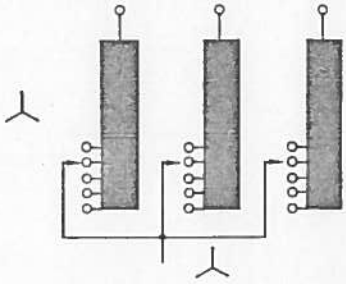
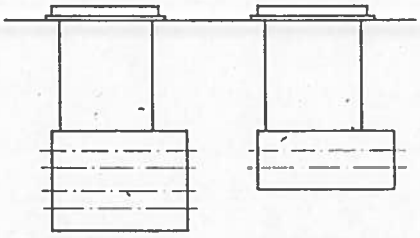
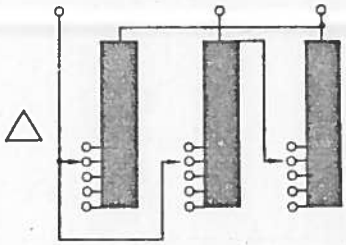
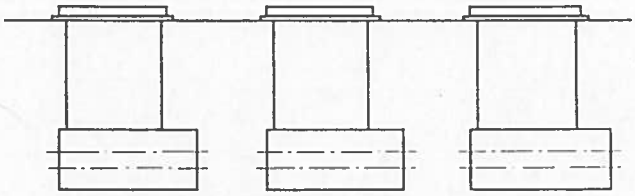
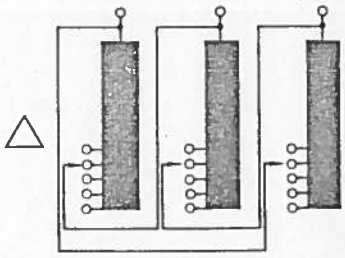
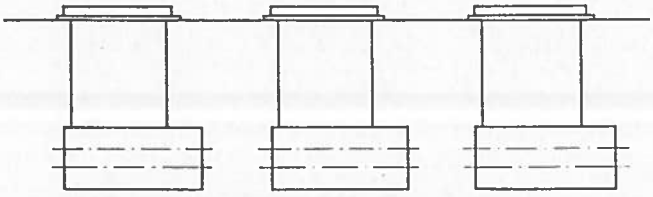
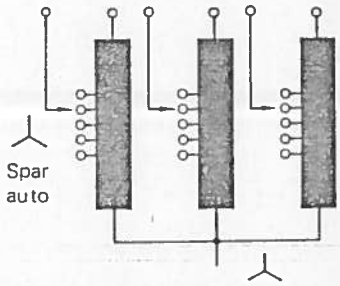
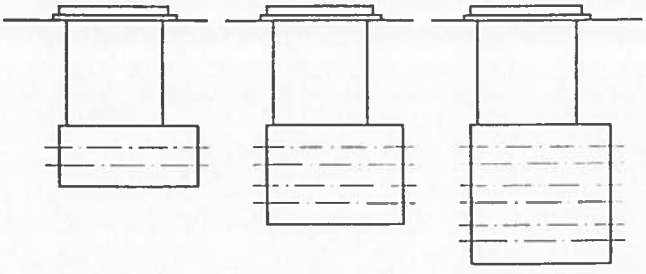
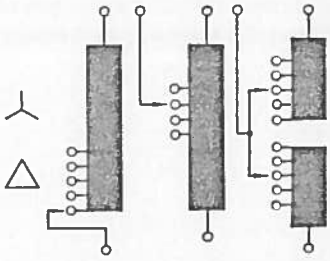
The main items of devices for installation in the control room are shown in **Reg. 8.01 to 8.09.**

4. Examples for selection and ordering data

From **Reg. 9.01** onwards there are given details.

5. Miscellaneous

Data, which belong to this passage, are given from **Reg. 9.51** onwards.

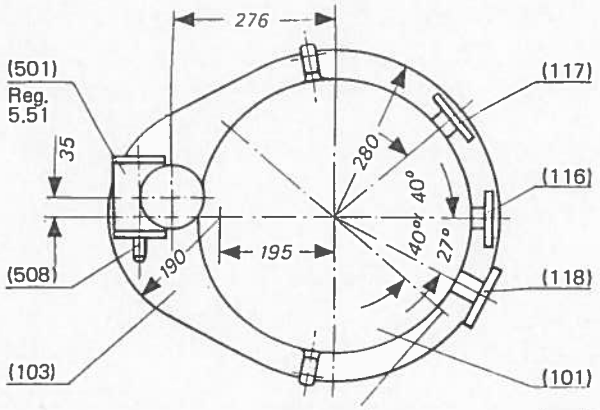
Stufenschalter-Typ On-load tap-changer type	Ausführung Design	Schaltung Connection
CRND **CRNG**	 6 Wählerebenen 6 selector levels	
XRSD **XRSG**	 4 Wählerebenen 4 selector levels 2 Wählerebenen 2 selector levels	
3 x ARSD **3 x ARSG**	 wahlweise 2, 4 oder 6 Wählerebenen pro Pol either 2, 4 or 6 selector levels per pole	
3 x ARSD **3 x ARSG**	 wahlweise 2, 4 oder 6 Wählerebenen pro Pol either 2, 4 or 6 selector levels per pole	 Spar auto
ARSD 1 **ARSG 1** **BRSD 2** **BRSG 2**	 1 1, 2 1	 1 1 2

Application of on-load tap-changer types

Verwendung der Stufenschaltertypen

Drawing-No.
4 026 152

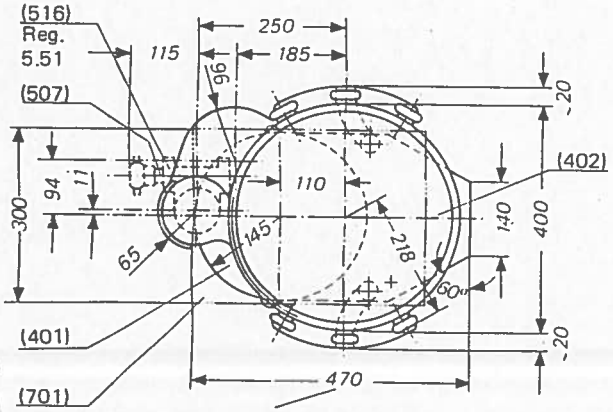
Zeichnungs-Nr.
4 026 152



Kabeleinführung
Cable entry

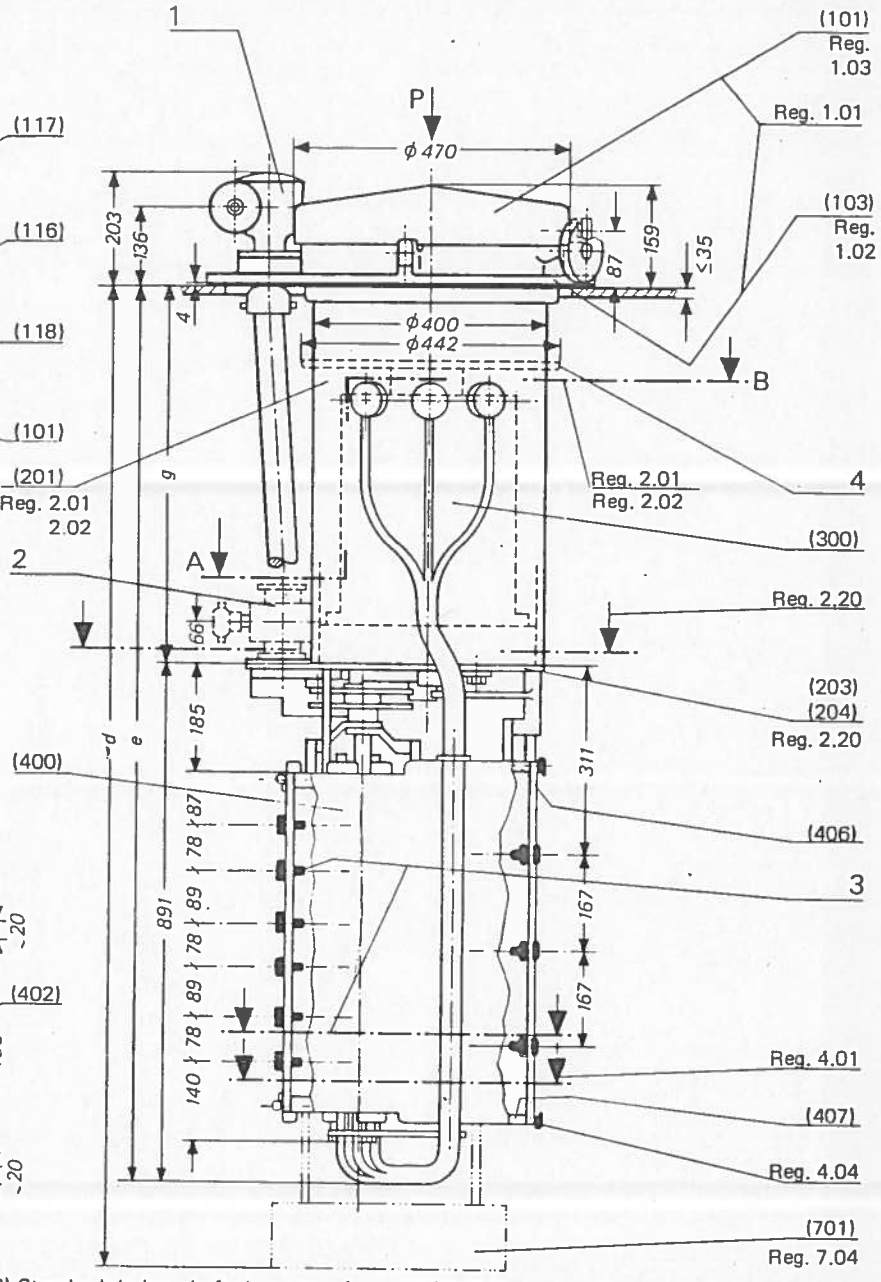
Ansicht P/View P

Druckwellenschutz (101) Reg. 1.03 kann gegenüber Deckelflansch (103) Reg. 1.02 um 18 x 20° gedreht werden.
Surge pressure protective device (101) Reg. 1.03 may be turned through 18 x 20° with respect to the top flange (103) Reg. 1.02.



Spannungskreis/Voltage circuit
(Maßüberschreitung möglich Reg. 4.20 - 4.24)
(The dimensions may be exceeded Reg. 4.20 - 4.24)

Schnitt A-B/Section A-B

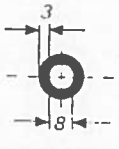


1 (500) Standard design, shaft above transformer cover. For possible arrangements of shafting, see Reg. 5.03 and 5.04.
2 (500) To special order, shaft below transformer cover. For possible arrangements of shafting, see Reg. 5.05.
3 For position of the insulating rods. see Reg. 0.90, contact arrangement, Reg. 4.20 to 4.24, contacts Reg. 4.02

1 (500) Normalausführung. Welle über Deckel. Anordnungsmöglichkeiten der Wellenführung Reg. 5.03 und 5.04.
2 (500) Sonderwunsch, Welle unter Deckel. Anordnungsmöglichkeiten der Wellenführung Reg. 5.05.
3 Lage der Isolierstäbe Reg. 0.90. Kontaktanordnung Reg. 4.20 bis 4.24, Kontakte Reg. 4.02.

Spalte/Column			1	2	3	4
Nenn-Stehwechselspannung nach Erde kV (eff) Rated power-frequency withstand voltage to earth kV (rms)			70	140	230	325
Maß/Dimension	g	(mm)	657	752	867	978
Maß/Dimension	e	(mm)	1548	1643	1785	1869
Maß/Dimension	d	(mm)	1699	1794	1909	2020
Abschirmung angebaut Screening fitted	Sternpunkt Neutral-point				•	•
	Einzelpol Single-pole				•	•

4 Abschirmung mit 3 mm Papierisolation
4 Screening with 3 mm paper insulating



Neutral point on-load tap-changer 200A
Single-pole on-load tap-changer 600A

Sternpunkt-Stufenschalter 200 A
Einzelpol-Stufenschalter 600A

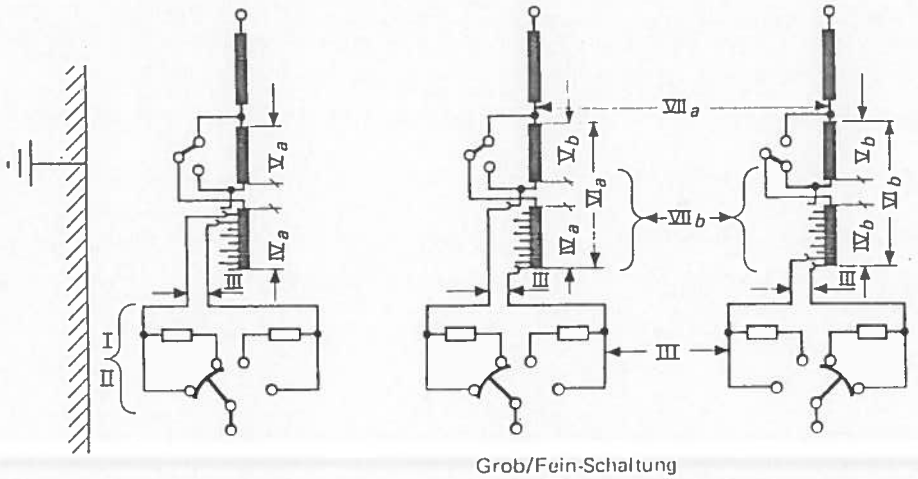
Basic Type I
Subassembly group 000

Basistyp I
Baugruppe 000

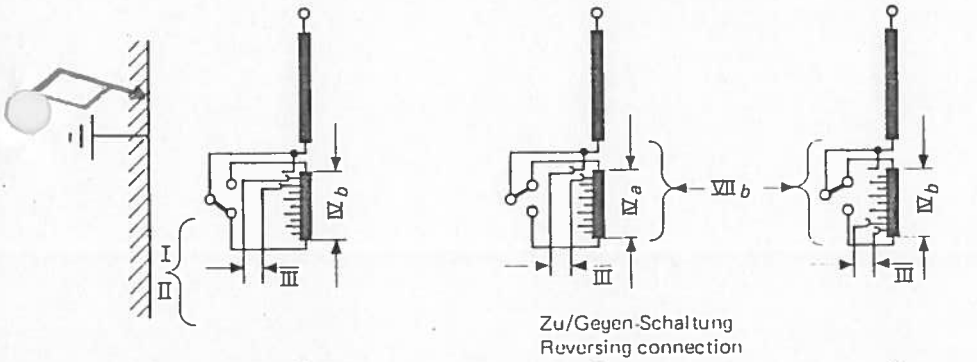
Drawing-No.
4 026 338

Zeichnungs-Nr.
4 026 338

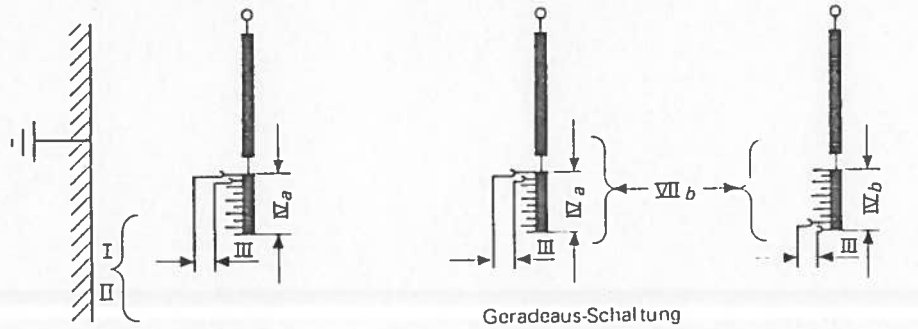
Cover mounti...



Grob/Fein-Schaltung
Coarse/fine connection



Zu/Gegen-Schaltung
Reversing connection



Geradeaus-Schaltung
Linear connection

Rated power-frequency withstand voltage kV (rms):
I = Diverter switch to earth

Rated lightning impulse withstand voltage $\hat{kV}$:
II = Diverter switch to earth
III = Between selected and preselected tapping just as between preselected and preselected tapping
IV = Across fine tapping winding
a) with freely oscillating winding
b) with current-carrying winding
V = Across the coarse tapping winding
a) with freely oscillating winding
b) with current-carrying winding
VI = Across the coarse tapping and fine tapping winding
a) with current-carrying coarse tapping and freely oscillating fine tapping winding
b) with current-carrying coarse tapping and fine tapping winding
VII = Between the phases
a) between the beginnings of the coarse tapping windings
b) between any other points of the coarse tapping and fine tapping windings

Nenn-Stehwechselspannung kV (eff):
I = Lastumschalter gegen Erde

Nenn-Stehblitzstoßspannung $\hat{kV}$:
II = Lastumschalter gegen Erde
III = Zwischen gewählter und vorgewählter sowie zwischen vorgewählter und vorgewählter Anzapfung
IV = Längs der Feinstufenwicklung
a) bei freischwingender Wicklung
b) bei stromdurchflossener Wicklung
V = Längs der Grobstufenwicklung
a) bei freischwingender Wicklung
b) bei stromdurchflossener Wicklung
VI = Längs der Grob- und Feinstufenwicklung
a) bei stromdurchflossener Grob- und freischwingender Feinstufenwicklung
b) bei stromdurchflossener Grob- und Feinstufenwicklung
VII = Zwischen den Phasen
a) zwischen den Anfängen der Grobstufenwicklungen
b) zwischen den übrigen beliebigen Punkten der Grob- und Feinstufenwicklungen

Insulating distances of the on-load tap-changer

Isolierstrecken des Stufenschalters

Drawing-No.
4 026 171

Zeichnungs-Nr.
4 026 171

Spalte Column				1	2	3	4	5
Wähler-Stabzahl Number of rods of selector				5	6	7	8	9
max. mögliche Stufenzahl Number of steps (max.)		ohne Vorwähler without change-over selector		9	11	13	15	17
		mit Vorwähler with change-over selector		±9	±11	±13	±15	±17
Isolierstrecke Insulating distance **Reg. a.61**	Benennung Designation			Nenn-Stehblitzstoßspannung 1,2/50 µs Rated lightning impulse withstand voltage 1,2/50 µs				
III [1]	Zwischen gewählter und vorgewählter sowie zwischen vorgewählter und vorgewählter Anzapfung Between selected and preselected tapping just as between preselected and preselected tapping		$k\hat{V}$	130 [1]	130 [1]	130 [1]	130 [1]	130 [1]
IV [2]	Längs Feinstufenwicklung Across fine tapping winding							
a	bei freischwingender Wicklung with freely oscillating winding		$k\hat{V}$	305	305	305	275	255
b	bei stromdurchflossener Wicklung with current-carrying winding		$k\hat{V}$	305	305	305	275	255
V	Längs Grobstufenwicklung Across the coarse tapping winding							
a	bei freischwingender Wicklung with freely oscilating winding		$k\hat{V}$	305	305	305	305	305
b	bei stromdurchflossener Wicklung with current-carrying winding		$k\hat{V}$	305	305	305	305	305
VI	Längs Grob- und Feinstufenwicklung Across the coarse tapping and fine tapping winding							
a	bei stromdurchflossener Grobstufenwicklung und freischwingender Feinstufenwicklung with current-carrying coarse tapping and freely oscillating fine tapping winding		$k\hat{V}$	400	390	380	400	400
b	bei stromdurchflossener Grob- und Feinstufenwicklung with current-carrying coarse tapping and fine tapping winding		$k\hat{V}$	350	350	350	350	350
VII	Zwischen den Phasen Between the phases							
a	zwischen den Anfängen der Grobstufenwicklungen between the beginnings of the coarse tapping windings		$k\hat{V}$	375	375	375	375	375
b	zwischen den übrigen beliebigen Punkten der Grob- und Feinstufenwicklungen between any other points of the coarse tapping and fine tapping windings		$k\hat{V}$	305	305	305	305	305

Remarks:
1. Usually the stress III is corresponding to the wave 1/5 µs. For this kind of wave the rated lightning impulse withstand voltage is as follows: 185 kV (1/5) in oil, resp. 150 kV (1/5) in ascarel.
By means of installation of voltage dependant resistors with resp. without spark gap higher occurent stresses may be limited by the permissible data.
2. Pay attention to Reg. a.60

Bemerkungen:
1. Die Beanspruchung bei III entspricht üblicherweise der Wellenform 1/5 µs. Für diese Welle sind die Nenn-Stehblitzstoßspannungen: 185 kV (1/5) in Öl bzw. 150 kV (1/5) in Askarel.
Durch den Einbau von spannungsabhängigen Widerständen (SAW) mit bzw. ohne Funkenstrecke können größere auftretende Beanspruchungen auf den zulässigen Wert begrenzt werden.
2. Beachte Reg. a.60.

Wählertypen/Types of selectors: 211

Selectors Basic Type I
Rated lightning impulse withstand voltages of the insulating distances for neutral-point and two-phase selectors

Wähler Basistyp I
Nenn-Stehblitzstoßspannungen der Isolierstrecken für Sternpunkt- und Zweiphasenwähler

Basic Type I

Drawing-No.
4 026 318

Basistyp I

Zeichnungs-Nr.
4 026 318

Spalte Column				1	2	3	4	5
Wähler-Stabzahl Number of rods of selector				5	6	7	8	9
max. mögliche Stufenzahl Number of steps (max.)		ohne Vorwähler without change-over selector		9	11	13	15	17
		mit Vorwähler with change-over selector		±9	±11	±13	±15	±17
Isolierstrecke Insulating distance **Reg. a.61**	Benennung Designation			Nenn-Stehblitzstoßspannung 1,2/50 µs Rated lightning impulse withstand voltage 1,2/50 µs				
III[1]	Zwischen gewählter und vorgewählter sowie zwischen vorgewählter und vorgewählter Anzapfung Between selected and preselected tapping just as between preselected and preselected tapping		$\hat{kV}$	130[1]	130[1]	130[1]	130[1]	130[1]
IV[2]	Längs Feinstufenwicklung Across fine tapping winding							
a	bei freischwingender Wicklung with freely oscillating winding		$\hat{kV}$	305	305	305	275	255
b	bei stromdurchflossener Wicklung with current-carrying winding		$\hat{kV}$	305	305	305	275	255
V	Längs Grobstufenwicklung Across the coarse tapping winding							
a	bei freischwingender Wicklung with freely oscillating winding		$\hat{kV}$	305	305	305	305	305
b	bei stromdurchflossener Wicklung with current-carrying winding		$\hat{kV}$	305	305	305	305	305
VI	Längs Grob- und Feinstufenwicklung Across the coarse tapping and fine tapping winding							
a	bei stromdurchflossener Grobstufenwicklung und freischwingender Feinstufenwicklung with current-carrying coarse tapping and freely oscillating fine tapping winding		$\hat{kV}$	400	390	380	400	400
b	bei stromdurchflossener Grob- und Feinstufenwicklung with current-carrying coarse tapping and fine tapping winding		$\hat{kV}$	350	350	350	350	350

Remarks:
1. Usually the stress III is corresponding to the wave 1/5 µs. For this kind of wave the rated lightning impulse withstand voltage is as follows: 185 kV (1/5) in oil, resp. 150 kV (1/5) in ascarel.
By means of installation of voltage dependant resistors with resp. without spark gap higher occurent stresses may be limited by the permissible data.
2. Pay attention to Reg. a.60

Bemerkungen:
1. Die Beanspruchung bei III entspricht üblicherweise der Wellenform 1/5 µs. Für diese Welle sind die Nenn-Stehblitzstoßspannungen: 185 kV (1/5) in Öl bzw. 150 kV (1/5) in Askarel.
Durch den Einbau von spannungsabhängigen Widerständen (SAW) mit bzw. ohne Funkenstrecke können größere auftretende Beanspruchungen auf den zulässigen Wert begrenzt werden.
2. Beachte Reg. a.60.

Wählertypen:
211, 411, 611
Types of selectors:
211, 411, 611

Selectors Basic Type I
Rated lightning impulse withstand voltages of the insulating distances for single-phase selectors

Wähler Basistyp I
Nenn-Stehblitzstoßspannungen der Isolierstrecken für Einphasenwähler

Basic Type I

Basistyp I

Drawing-No.
4 026 374

Zeichnungs-Nr.
4 026 374

Spalte Column			2	3	4
Reihenspannung nach VDE 0111 System nominal voltage to VDE 0111		30 N	60 N	110 N	150 N
Höchste Spannung für Betriebsmittel U_m System highest voltage U_m	kV (eff) kV (rms)	36	72,5	125	170
Nenn-Stehwechselspannung nach Erde (Isolierstrecke I nach Reg. a.61) Rated power-frequency withstand voltage to earth (Insulating distance I in according with Reg. a.61)	kV (eff) kV (rms)	70	140	230	325
Nenn-Stehblitzstoßspannung unter Öl oder Askarel, Vollwelle (1,2/50 µs) (Isolierstrecke II nach Reg. a.61 Rated lightning impulse withstand voltage in oil/ascarel, full wave (1,2/50 µs) (Insulating distance II in according with Reg. a.61)	kV	200	325	550	750
Nenn-Stehblitzstoßspannung unter Öl oder Askarel, abgeschnittene Welle (Isolierstrecke II nach Reg. a.61) Rated lightning impulse withstand voltage in oil or ascarel, chopped wave (Insulating distance in according with Reg. a.61)	kV	230	375	630	860

Für Lastumschaltergefäßtyp 211, 411, 611
For diverter switch tank type 211, 411, 611

Diverter switch tanks
Basic Type I
Rated withstand voltages to earth

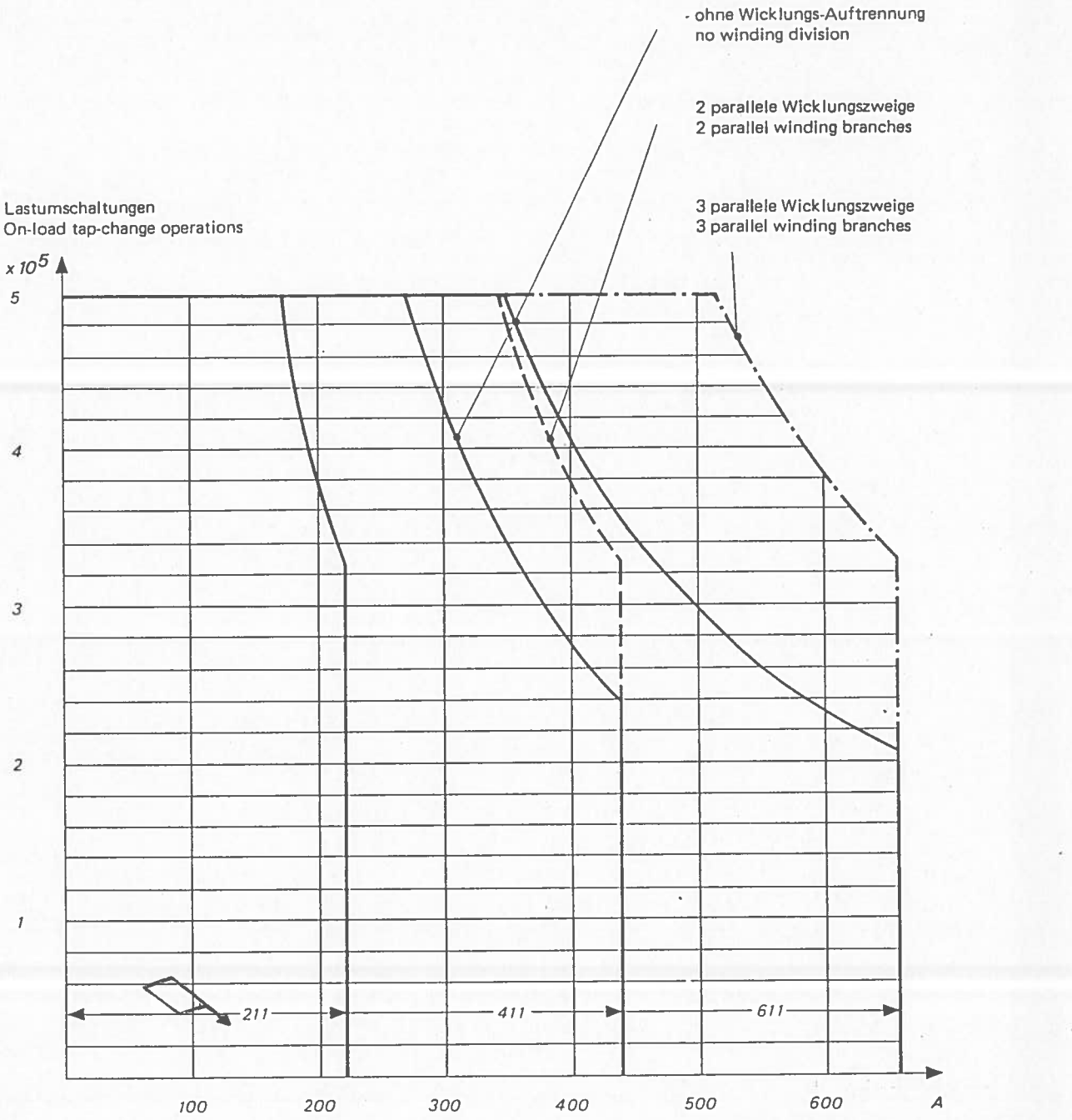
Lastumschaltergefäße
Basistyp I
Nenn-Stehspannungen gegen Erde

Basic Type I

Basistyp I

Drawing-No.
4 026 320

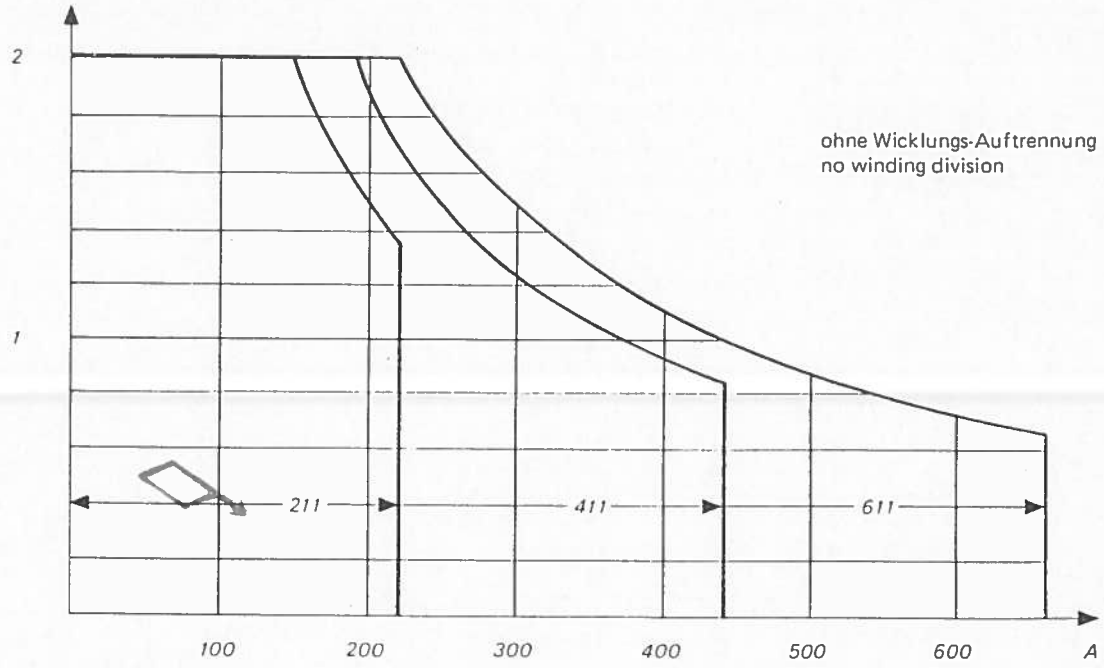
Zeichnungs-Nr.
4 026 320



Für Lastumschaltertypen 211, 411, 611

For diverter switch types 211, 411, 611

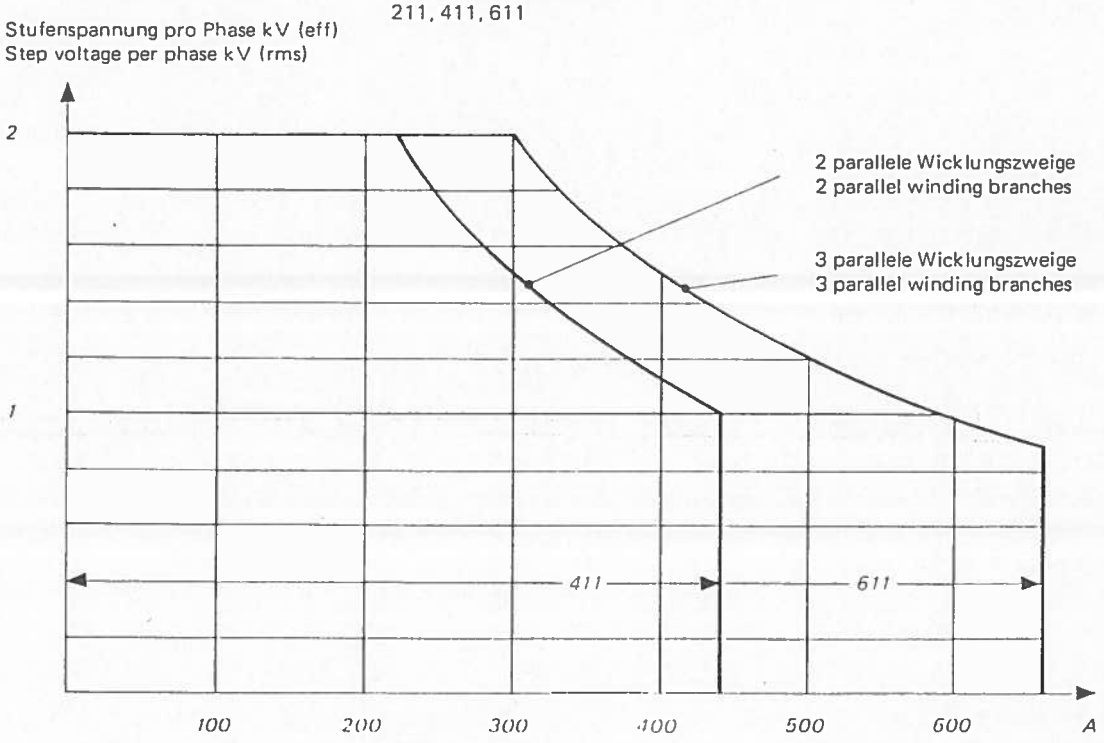
Diverter switch Basic Type I **standard design** **Contact life according to type and load current of diverter switch**	**Lastumschalter Basistyp I** **Normalausführung** **Kontaktlebensdauer abhängig vom Typ und Belastungsstrom des Lastumschalters**	Basic Type I **Drawing-No.** **4 026 325**	Basic Type I **Zeichnungs-Nr.** **4 026 325**



ohne Wicklungs-Auftrennung
no winding division

Max. Anzapfungsstrom des Transformators
Max. tapping current of transformer

Für Lastumschaltertypen
211, 411, 611
For diverter switch types
211, 411, 611



2 parallele Wicklungszweige
2 parallel winding branches

3 parallele Wicklungszweige
3 parallel winding branches

Für Lastumschaltertypen
411, 611
For diverter switch types
411, 611

Max. Anzapfungsstrom des Transformators
Max. tapping current of transformer

Diverter switch Basic Type I
Load characteristic curves

Lastumschalter Basistyp I
Belastungskennlinien

Basic Type I

Basistyp I

Drawing-No.
4 026 326

Zeichnungs-Nr.
4 026 326

Spalte Column			1	2	3
Wählertyp Selector type			211	411	611
Lastumschaltertyp Diverter switch type			211	411	611
Maximaler Nennstrom des Stufenschalters Maximum rated through-current of on-load tap-changer		A	200	400	600
Typ CRND, CRNG Type CRND, CRNG	Wählerebenen je Pol Selector levels per pole		6	–	–
	Pole Poles		1	–	–
Typ XRSD, XRSG Type XRSD, XRSG	Wählerebenen je Pol Selector levels per pole		4/2	–	–
	Pole Poles		2	–	–
Typ ARSD, ARSG Type ARSD, ARSG	Wählerebenen je Pol Selector levels per pole		2	4	6
	Pole Poles		1	1	1
Typ 3 x ARSD, 3 x ARSG Type 3 x ARSD, 3 x ARSG	Wählerebenen je Pol Selector levels per pole		2	4	6
	Pole Poles		3	3	3
max. zulässiger Dauerstrom max. permissible constant current		A	220	440	660
max. zulässige Stufenspannung max. permissible step voltage		V	2000	2000	2000
Kurzzeitstrom (2s) Short-circuit current (2s)	ohne Wicklungsaufteilung no winding division	kA	3,3	5	7
	mit Wicklungsaufteilung with winding division	kA	–	6,6	9,9
Scheitelwert des Kurzzeitstromes Peak value of short-circuit current	ohne Wicklungsaufteilung no winding division	$k\hat{A}$	8,25	12,5	17,5
	mit Wicklungsaufteilung with winding division	$k\hat{A}$	–	16,5	24,7
Nennfrequenz Rated frequency		Hz	50 bis/to 60		
Belastungskennlinien für Lastumschalter Load characteristic curves of diverter switches			Reg. a.41		
Nenn- Stehblitzstoßspannungen für: Rated lightning impulse withstand voltages for:					
Stufenschalter allgemein On-load tap-changer generally			Reg. a.43, a.50, a.51, a.62, a.63		
Stufenschalter gewählte – vorgewählte Anzapfung On-load tap-changer selected to preselected tapping			80 $k\hat{V}$ 1,2/50 bzw./resp. 110 $k\hat{V}$ 1/5 µs		
Betriebsstellungen Operating positions			ohne Vorwähler max. 18 without change-over selector max. 18 mit Vorwähler max. 35 with change-over selector max. 35	Schaltarten Characteristic connections Reg. a.72 bis/to a.76	
Einsatzbereich Operating temperature range	Normal Standard design		– 25° C bis/to 100° C		
	Sonderausführung Special design		– 40° C bis/to 100° C		

On-load tap-changer
Basic Type I
Currents, voltages and operating positions

Stufenschalter
Basistyp I
Ströme, Spannungen und Betriebsstellungen

Basic Type I

Basistyp I

Drawing-No.
4 026 223

Zeichnungs-Nr.
4 026 223

Spalte Column			1	2	3
Wählertyp Selector Type			211	411	611
Maximaler Nennstrom Maximum rated through-current		A	200	400	600
Max. zulässiger Dauerstrom Max. permissible constant current		A	220	440	660
Kurzzeitstrom (2s) Short-circuit current (2s)	ohne Wicklungsaufteilung no winding division	kA	3,3	5	7
	mit Wicklungsaufteilung with winding division	kA	–	6,6	9,9
Scheitelwert des Kurzzeitstromes Peak value of short-circuit current	ohne Wicklungsaufteilung no winding division	$k\hat{A}$	8,25	12,5	17,5
	mit Wicklungsaufteilung with winding division	$k\hat{A}$	–	16,5	24,7
Nenn-Stehblitzstoßspannung der Isolierstrecke III unter Öl nach Reg. a.61	1,2/50 µs	$k\hat{V}$	130	130	130
Rated lightning impulse withstand voltage across insulating distance III in oil, in accordance with Reg. a.61	1/5 µs	$k\hat{V}$	185	185	185

Selector Basic Type I
Currents and rated lightning impulse withstand voltages

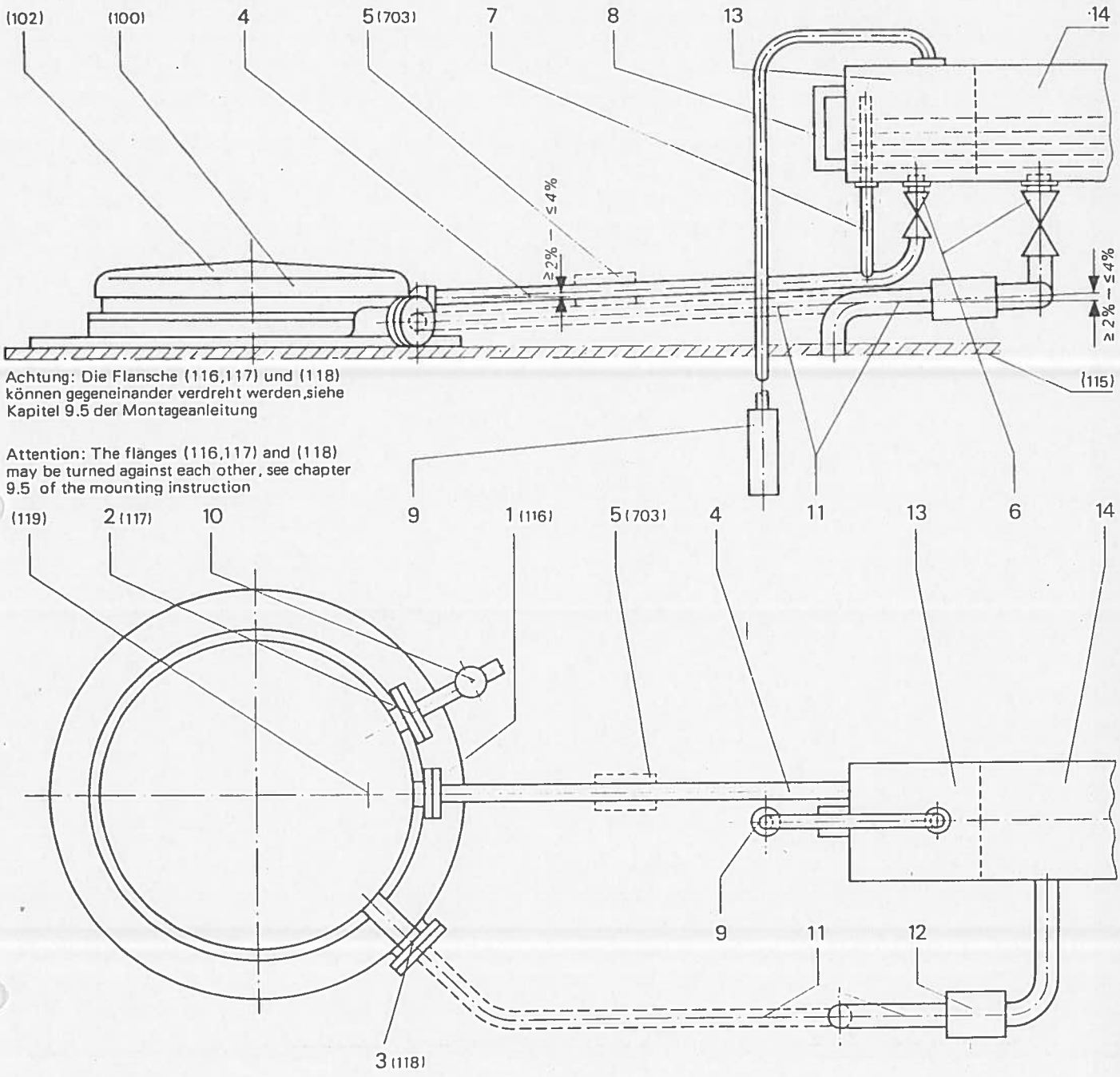
Wähler Basistyp I
Ströme und Nenn-Stehblitzstoßspannungen

Basic Type I

Basistyp I

Drawing-No.

Zeichnungs-Nr.



Achtung: Die Flansche (116,117) und (118) können gegeneinander verdreht werden,siehe Kapitel 9.5 der Montageanleitung

Attention: The flanges (116,117) and (118) may be turned against each other, see chapter 9.5 of the mounting instruction

1 Oil inlet flange (116)
2 Oil drain flange (117)
3 Gas discharge flange (118)
4 Pipeline to the oil conservator for diverter switch
5 Protective relay for diverter switch (703)
6 Valve
7 Over flow pipe
8 Oil level indicator
9 Dehydrator
10 Oil drain valve
11 Pipeline to the conservator of the transformer
12 Buchholz-relay of the transformer
13 Conservator for oil of the diverter switch
14 Conservator for insulating liquid of the transformer

1 Flansch für Ölzulauf (116)
2 Flansch für Ölabsenken (117)
3 Flansch für Gasableitung (118)
4 Rohrleitung zum Ausdehnungsgefäß für den Lastumschalter
5 Schutzrelais für Lastumschalter (703)
6 Absperrschieber
7 Überlaufleitung
8 Ölstandanzeiger
9 Luftentfeuchter
10 Ventil zum Ölabsenken
11 Rohrleitung zum Ausdehnungsgefäß für Transformator
12 Buchholz-Relais des Transformators
13 Ausdehnungsgefäß für Lastumschalteröl
14 Ausdehnungsgefäß für Transformator-isolierflüssigkeit

(100) Stufenschalterkopf
(115) Transformatordeckel
(119) Entlüftungsschraube, nach Abnehmen der Haube (102) zugänglich

(100) On-load tap-changer, top section
(115) Transformer cover
(119) Vent srew, accessible after taking off the cover (102)

Mounting of the pipelines (128) for one pole of an on-load tap-changer Basic Type I and II

Anbau der Rohrleitungen (128) für einen Stufenschalterpol Stufenschalter Basistyp I und II

Basic Type I, II	Basistyp I, II
Subassembly group 100	Baugruppe 100
Drawing-No. 4 026 118	Zeichnungs-Nr. 4 026 118

Trafo-Union

Motor-drive mechanism MA-E/4

Operating Instructions

Contents

1. General

The function of the motor-drive mechanism is to set the on-load tap changers or off-circuit tap changers at the desired operational setting. The mechanical and electrical parts required to operate both types of tap changer are all accommodated in the housing. Control is based on the step-by-step principle. The motor drive mechanism is suitable for operation in fully automated system substations and for operation in parallel. Electrical and mechanical safety devices prevent overrunning of the end positions. Automatic restart after power interruptions is provided. Drive motors for various voltages and currents can be supplied (see **Table 1**, page 3).

The drive complies with the following specifications and standards: IEC 214, DIN 57532 Part 30, VDE 0532 Part 30, VDE 0530, IEC 337-1, DIN 57660, VDE 0660, DIN 57106 Part 100, VDE 0106 Part 100.

Numbers from 1 to 99 in ( ) refer to current path numbers in the circuit diagram (see, for instance, **Figure 14**, page 21). Numbers from 200 on refer to the mechanical parts of the motor drive, see **Figure 2**, page 5 and **Figure 5**, page 7.

Electrical data		see rating plate and circuit diagram		
Permissible operating voltage range		80 . . . 110% of rated voltage		
Permissible frequency range		90 . . . 105% of rated frequency		
Test voltage for all live terminals against metal parts of drive		2 kV_{eff}, 50 Hz, 1 min. (except drive motor)		
Number of power take-off shaft (203) revolutions per tap-change		8		
Number of hand crank (601) revolutions per tap-change		8		
Total weight of drive mechanism		ca. 50 kg		
Noise levels		Measured at 1 m	Measured at 3 m	
Switch-on noise		62 dB(A)	59 dB(A)	
Running noise		52 dB(A)	50 dB(A)	
Switch-off noise		65 dB(A)	62 dB(A)	
Number of service tapping positions		max. 39, min. 3		
Permissible ambient temperature		−25 °C to +55 °C		
Rated frequency		50 Hz	60 Hz	d.c.
Running time per tap-change, approx.		4.5 s	4.0 s	4.5 s
Power consumption of the control circuit				
On switching on (2 contactors), approx.		140 VA	140 VA	17 W
In switch-on position (3 contactors), approx.		30 VA	30 VA	25 W
Type of motor	3 a. c.	0.25 kW	0.25 kW	———
Power rating	1 a. c.	0.20 kW	0.20 kW	———
for other data, see **Table 2**	d.c.	———	———	0.25 kW
Perm. momentary	3 a.c.	21 Nm	17 Nm	———
torque at the	1 a.c.	17 Nm	14 Nm	———
drive shaft, approx.	d.c.	———	———	21 Nm

Table 1: Output data of the motor-drive mechanism.

Circuit of the motor				Δ/Y	Δ/Y	Δ/Y	Δ
Hz	Rated power	Rated voltage		-/170-220 V	185-210 V/320-365 V	220-255 V/380-440 V	230 V
50	0.25 kW / 0.20 kW	Rated current	3 a.c.	-/1.90-2.23 A	1.78-2.03 A/1.03-1.17 A	1.47-1.70 A/0.85-0.98 A	-
			1 a.c.	-/-	-/-	-/-	1.6 A
Hz	Rated power	Rated voltage		-/200-240 V	220-250 V/380-435 V	255-305 V/440-530 V	V
60	0.25 kW / 0.20 kW	Rated current	3 a.c.	-/1.72-2.20 A	1.63-1.96 A/0.94-1.13 A	1.33-1.60 A/0.77-0.97 A	-
			1 a.c.	-/-	-/-	-/-	A
d. c.	Rated power	Rated voltage		110 V	125 V	220 V	
	0.25 kW	Rated current		3.20 A	2.80 A	1.60 A	

Start-up current approx. 3 x rated current

3. Design and components

3.1 Mechanical design

3.1.1 Housing (**Figure 1**)

The cabinet (610) and the door (620) are made of weather-resistant, hot-pressed, polyester resin reinforced with glass-fibre. All other external parts are made of stainless steel, corrosion-proof or weather-resistant materials. The door (620) is hinged on the right-hand side. The ventilation (621) of the housing is provided by labyrinth openings, one at the top and one at the bottom of the cabinet. The openings are covered with a fine mesh grid. The housing corresponds to protection class IP 45, IEC 144 and DIN 40050.

3.1.2 Gear unit (**Figure 5**)

3.1.2.1 Load gear (200)

V-ribbed belt gear, low-noise and virtually maintenance-free. Reduction ratio 1 : 6.5.

3.1.2.2 Control gear (300)

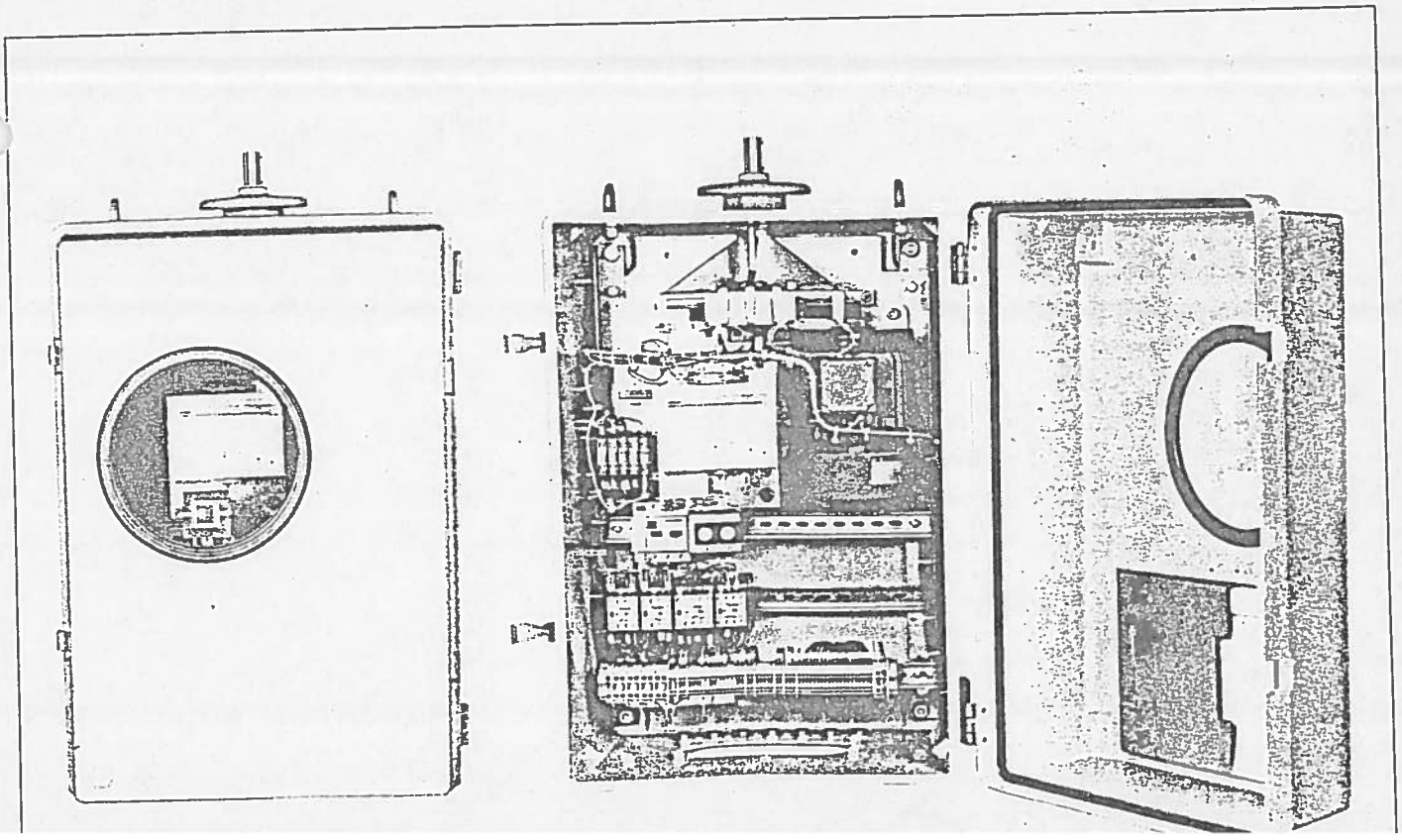
Maintenance-free, two-step worm gear.

A step-by-step shaft (301) with one revolution per step is provided at the control gear (300) to control the step operation and to indicate the position. A second shaft with 1/40 turn per step (310) is provided for monitoring purposes. The step-by-step operation is controlled by the 301 with one revolution per step by means of step-by-step cams (302) which operate the respective snap switches. On the shaft with 1/40 revolution per step (310) there is the positioning wheel (313) and a contact range plate with the multicontact dial switch S16 and the resistance tele-transmitter R1 (**Figure 6**, page 8). Another contact range plate with 2 multi-contact dial switches may be added.

3.1.2.3 Mechanical end stop (**Figure 3** and **Figure 5**)

The positioning wheel (313) has two end-position cams (312). If an end position is passed (e.g. during manual operation or due to a defect) the chock lever (326) shifts the chock (204) into the appropriate blocking position.

Figure 1 Motor drive mechanism Shown with housing closed and open



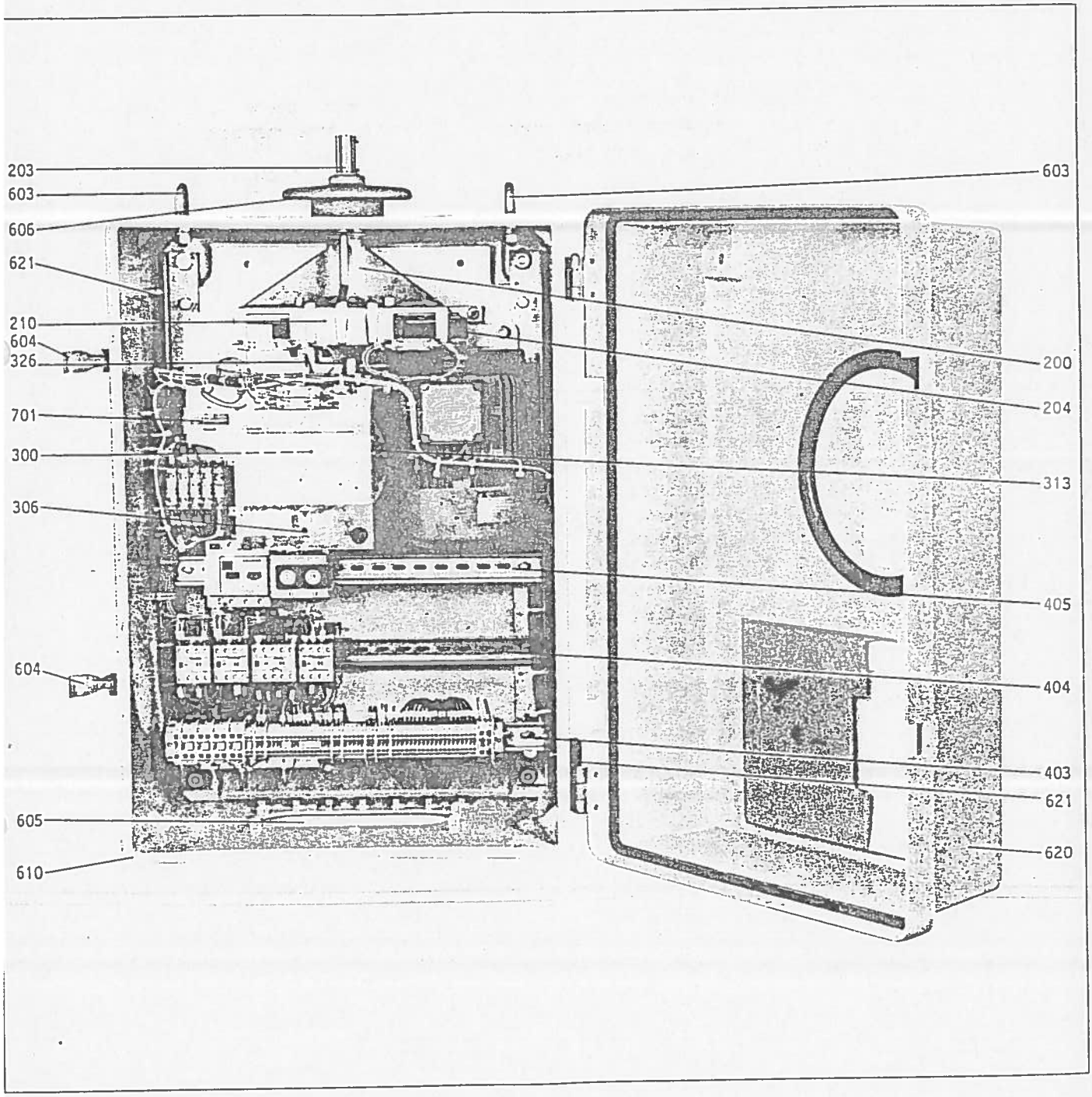
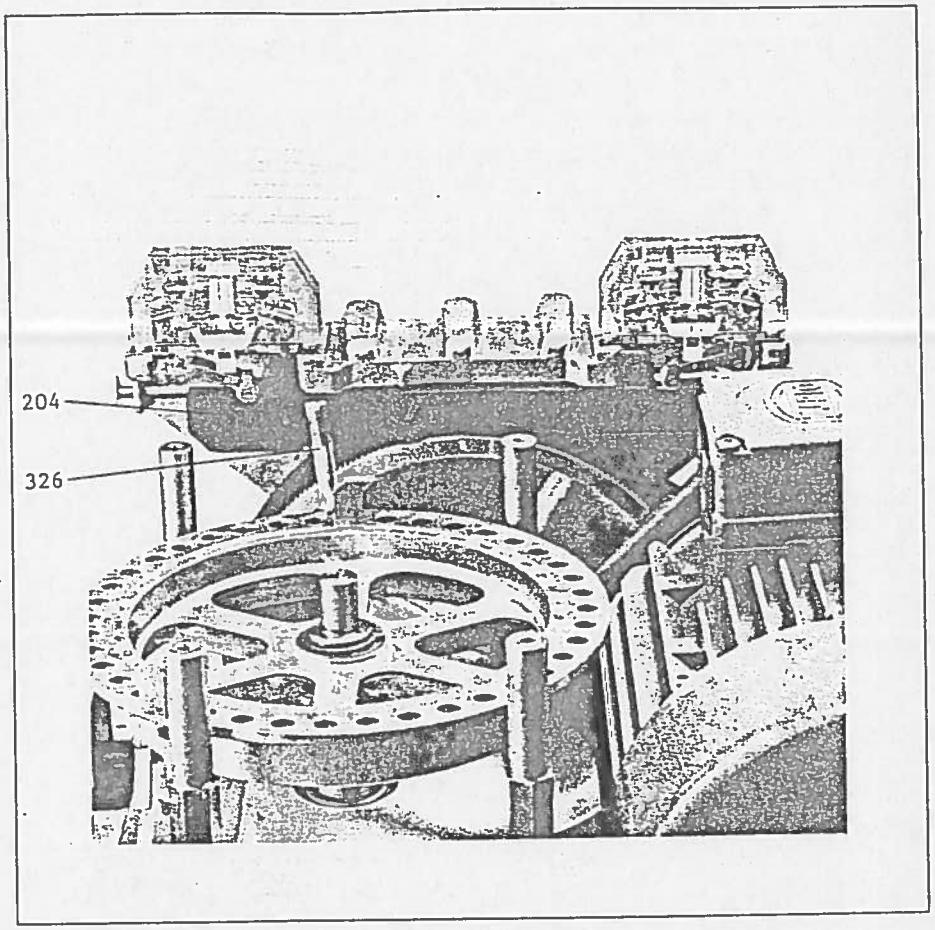


Figure 2 Mechanical equipment

200 *Load gear*
203 *Power take-off shaft*
204 *Chock*
210 *Mark indicating chock position*
300 *Control gear*
306 *Indicator triangle*
313 *Positioning wheel*
326 *Chock lever*
403 *Terminal strip*
405 *Control element strip*
603 *The transportation eye-bolts*
604 *Door lock*
605 *Connection plate*
606 *Handwheel*
610 *Cabinet*
620 *Door*
621 *Air vents*
701 *Counter*

Figure 3 Mechanical end stop with chock (204) and chock lever (326)



After not more than 2.5 revolutions, the power take-off shaft (203) will be mechanically stopped from moving in the direction of operation. The movement of the chock (204) switches off the motor drive through the motor protection switch Q1 via the security switch S40. During manual operation the mechanical end stop remains operative even if the belt is damaged or torn (missing altogether).

3.1.3 Counter (701) (**Figure 4**)
Electromechanical, re-settable, 6-digit pulse counter. The counter can be read with the door (620) closed.

3.1.4 Connection plate (605) for cable insertion
Standard model: Screws for cables to DIN 46320 (**Figure 13**, page 20).

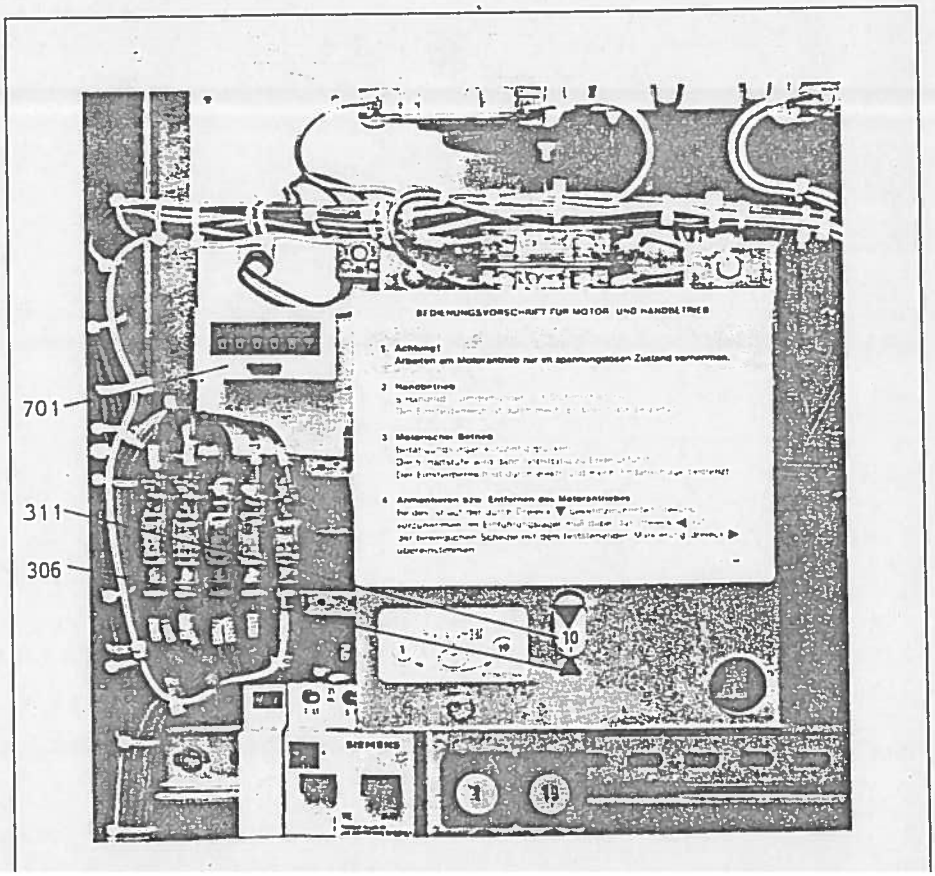


Figure 4 Tap position indicator on the tap position indicator disc (311),

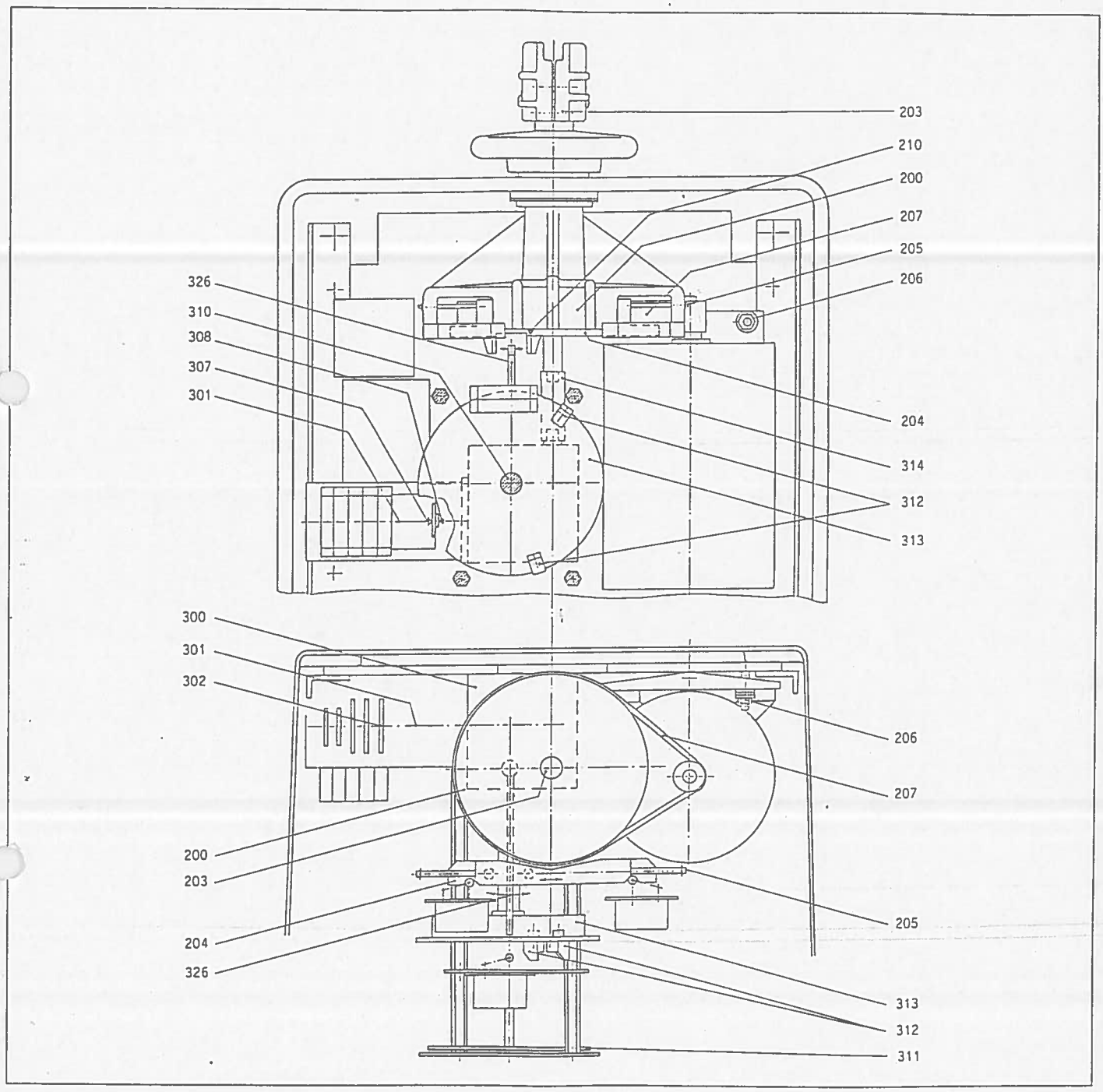


Figure 5 Load gear and control gear

200 Load gear
203 Power take-off shaft
204 Chock
205 Chock axle
206 Nut to tighten V-ribbed belt
207 V-ribbed belt
210 Mark indicating chock position
300 Control gear
301 Step-by-step shaft
302 Step-by-step disc
307 Positioning triangle
308 Position mark
310 Shaft with 1/40 revolution per step
311 Tap position indicator disc
312 End position cam
313 Positioning wheel
314 Coupling
326 Chock lever

3.2 Electrical equipment (**Figure 6**)

D1 Electromechanical pulse counter

E1 Heating element
output 50 W

K1, K2 Motor contactor — 3-pole each, auxiliary contacts:

K5 Step-by-step contactor — 2 NO contacts, 2 NC contacts

K4 Motor brake contactor
Contacts:
5 NO, 5 NC contacts

M1 Driving Motor
see page 3, **Tables 1** and **2**

Q1 Motor protection switch with thermal and magnetic release of the operating current.
Setting: see page 3, **Table 2**
Auxiliary contacts:
1 NO, 1 NC contact

R1 Resistance tele-transmitter, total resistance approx. 200 ohms.
Step resistance:
metal layer resistance:
±1%, 0.7 W

S1, S2 Push-button for step-by-step control:
1 NO, 1 NC contact

S8, S9 Limit switches

S11, S12 Direction of rotation contacts (dependent on the direction of rotation)
Snap-switches with forced opening of the NC contact.
Two-circuit change-over contact:
1 NO, 1 NC contact

S16 Multi-contact dial switch. The ring and one contact for each position of the motor drive are connected, with the voltage off, to the terminal strip X10.
Permissible loads are shown on page 10, **Table 5**.

S35, S36 Control contacts
each with a snap switch with forced opening of the NC contact.
Two-circuit change-over contact:
1 NO, 1 NC contact for each

S37 Auxiliary contact
Snap switch with forced opening of the contact NC contact.
One-circuit change-over contact:
1 NO, 1 NC contact

S40 Security switch
Snap switch with forced opening of the NC contact.
Two-circuit change-over contact:
1 NO, 1 NC contact each

X10 Terminal strip
Standard version with screwless series terminals for all types of cable.
For connection, see **Figure 7**.
Snapped on mounting rail 35 x 15, like DIN EN 50022.
Insulation voltage = 500 V
Contamination class 3
VDE 0190
Connection data is shown on **Table 3**.

	Model without auxiliary contact overlapping			**Model** with auxiliary contact S37 interrupting			
	voltage U_e	current I_e cos φ = 1	T^2) = 0 ms	voltage U_e	current I_e cos φ ≧ 0.4	T^2) = 0 ms	T^2) = 5 m
	110 V a.c.	0.7 A	——	240 V a.c.	5 A	——	——
	240 V a.c.	0.3 A	——	60 V a.c.	——	5 A	4.2 A
	60 V d.c.	——	0.8 A	110 V d.c.	——	4 A	2.1 A
				110 V d.c.	——	5 A[3])	5 A[3])
				220 V d.c.	——	1 A	0.6 A
				220 V d.c.	——	1.3 A[3])	0.8 A[3])
U_i[1])	240 V[4]) a.c./d.c.	——	——	240 V[4]) a.c./d.c.	——	——	——
U_i[1])	300 V[5]) a.c./d.c.	——	——	300 V[5]) a.c./d.c.	——	——	——

1) Rated insulation voltage U_i to VDE 0109, dirt accumulation class 2

2) $T = \frac{L}{R}$

3) Auxiliary and switch-over contact with blow cap

4) Inner multi-contact range

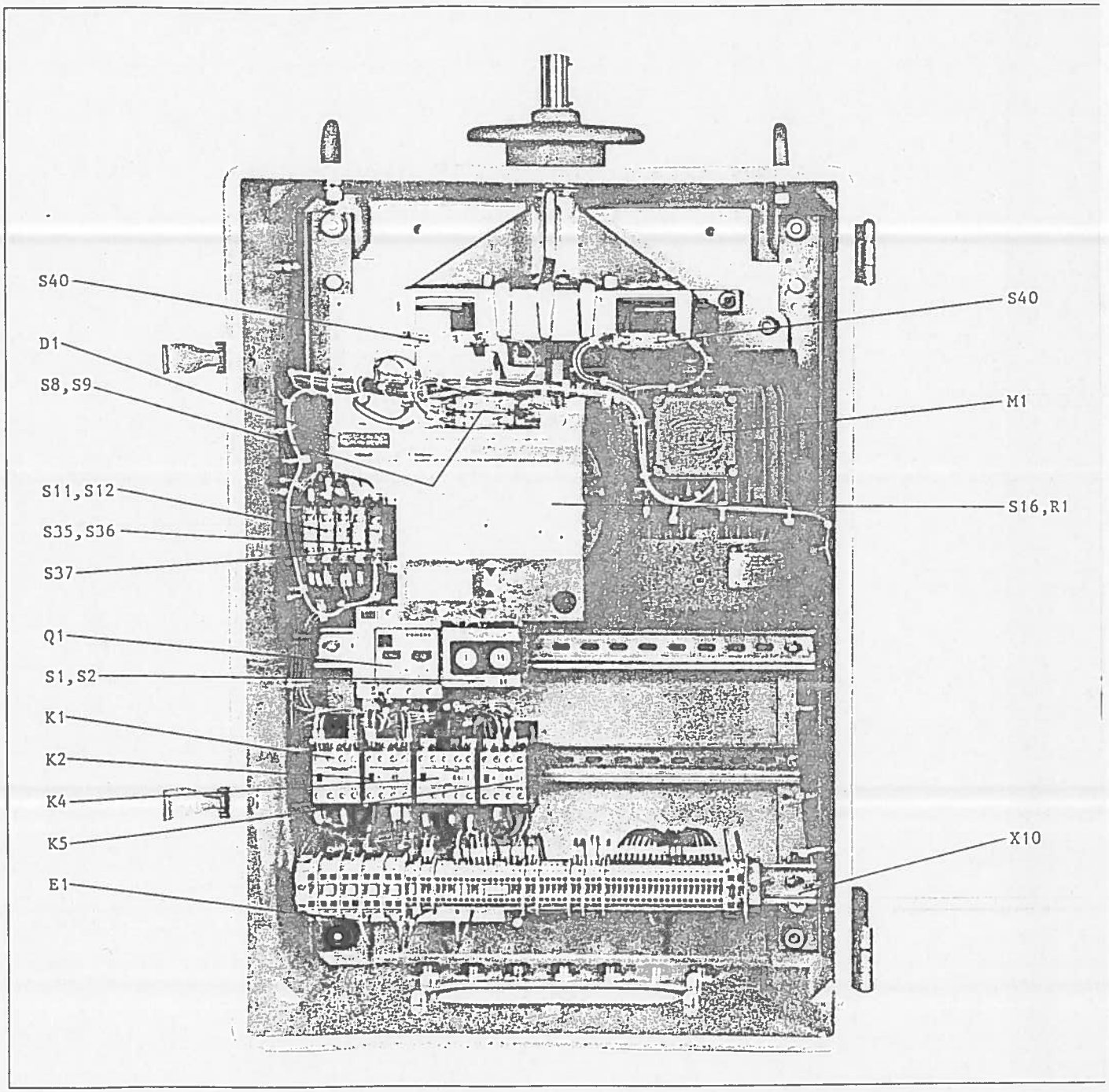
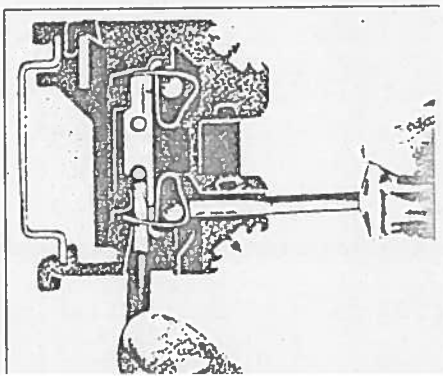
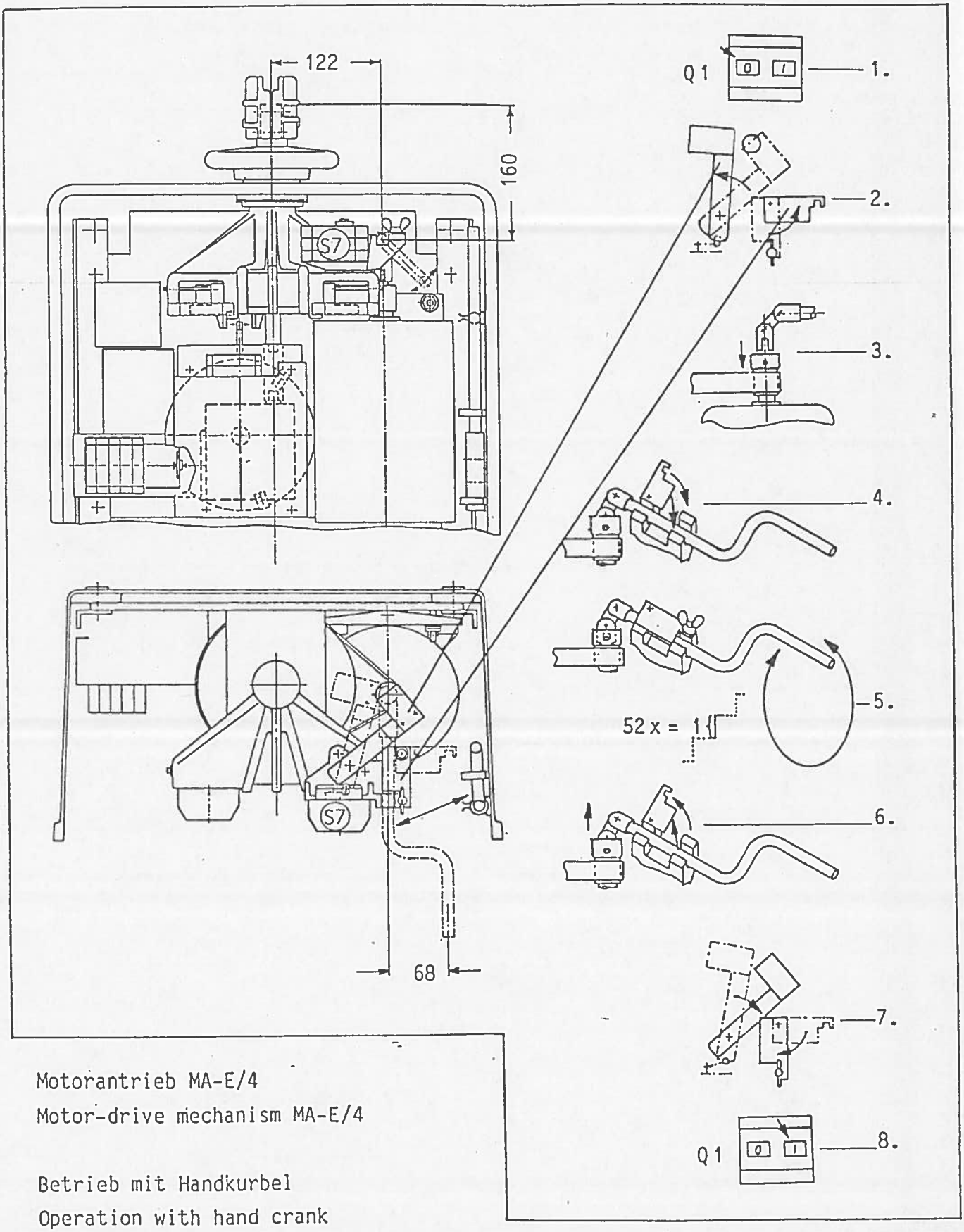


Figure 6 Electrical equipment, for description see 3.2

Figure 7 Connecting terminals without screws



Wiring in the drive	Motor circuit	Control circuit with monitor- and indicator circuit	Protective earth conductor
Wire: extra flexible with end sleeve	1.5–4 mm²	1.0–1.5 mm²	1.5–4 mm²



Motorantrieb MA-E/4
Motor-drive mechanism MA-E/4

Betrieb mit Handkurbel
Operation with hand crank

4.1 Electrical circuits

4.1.1 Series fuses

The drive supply lines are to be equipped with the state of the art fuses to provide reliable protection for equipment and cables in the drive.
See Table 4.

	DIAZED T	Miniatur circuit breaker to VDE 0660 T101 I_k = 1000 A
M[illegible] circuit Con[illegible] circuit	6 A	6 A
Monitor Heater	6 A	6 A
Multi-contact dial switch Resistance tele-transmitter	6 A	6 A

Control circuit: if the control voltage is derived away from the motor circuit no extra series fuse is necessary.

Table 5: Maximum permissible series fuses.

4.1.2 Motor power circuit (1, 2)

The motor drive mechanism M1 terminals designated U, V, W are connected to the three-phase lines L1, L2, L3 via the motor protection switch Q1 and the motor brake contactor K4 (three-phase) and via the motor contactors K1 and K2 respectively (two-phase).

4.1.3 Control circuit (11 to 40)

The control circuit is supplied with operating voltage via the contacts of the motor protection switch Q1 or from outside via a Q1 NO contact. If Q1 responds or is triggered, the control voltage is interrupted.

4.1.4 Power circuit for multicontact dial switch S16 (72)

The connections to the outer contact range are led to the terminal strip – terminals 50 to 50 + n – and are freely available for, e.g., position indication with a lamp panel, supervision of parallel operation, other types of supervision.

4.1.5 Resistance tele-transmitter R1 (71)

The position is indicated via the resistance tel-transmitter R1 with its step resistances, e.g. by means of a cross-coil instrument. The R1 is connected to terminals 37–39 (71).

4.1.6 Progress lamp H1 (50)

A progress lamp can be connected to terminal 29 (50) so that progress can be observed from the control room. The voltage must be supplied via terminal 28 (50).

4.1.7 Stop contact S6

The motor protection switch Q1 is released in the drive by its own push-button "0" or by the stop contact S6 (13) in the control room.

4.1.8 Overcurrent blocking

The drive is ready for connection to an overcurrent blocking device at terminals 21 and 22. The bridge between the two terminals must be removed for this purpose. The feeder to the control circuit is interrupted when the overcurrent blocking responds. The drive is no longer operable. The blocking contact S6 (13) still functions, however.

4.2 Switching operations (Figures 8a, b, c, d, e and Figure 14, page 21)

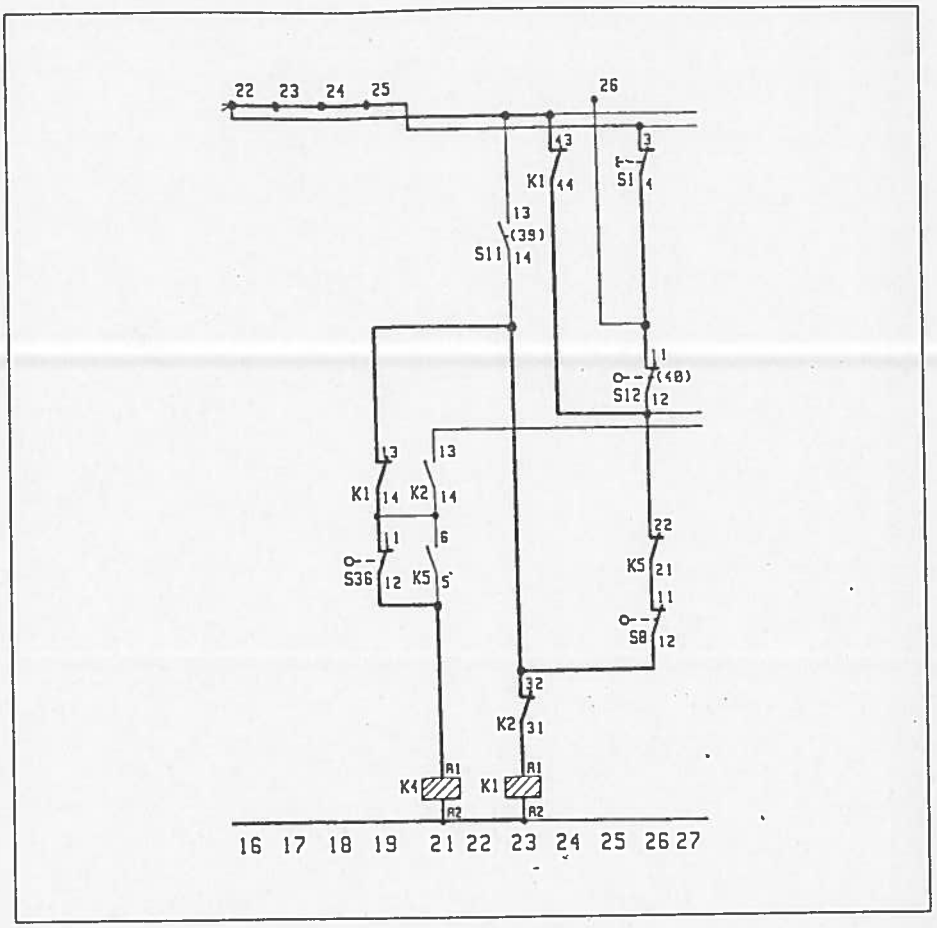
4.2.1 Control to "1" or to "n"

Step-by-step control: The motor drive is designed on the step-by-step principle, i.e. once the pulse has been emitted, the step is performed automatically and irrevocably to completion, irrespective of whether other control pulses are emitted at the push-buttons for step-by-step switching S1 (26), S2 (36), during operation or not.

Step-by-step switching: The direction of rotation contacts S11 and S12 (depending on the direction of rotation) and the control contacts S35 and S36 (independent of the direction of rotation) are operated in a specified sequence via the control gear. (Figure 8e, page 13)

Conditions: The motor protection switch Q1 (1), limit switches S8 (26) and S9 (36) closed, the security switches S40 (14, 15) unoperated. Voltage (three-phase current) at L1, L2, L3, phase sequence clockwise.

Figure 8a Operation of the push button for step-by-step switching



Operation: Press button for step-by-step switching "1" S1 (26) (**Figure 8a**). Via the closed contacts of the step-by-step contactor K5 22-21 (26) and the limit switch S8 11-12 (26), the motor contactor K1 immediately picks up and closes contacts 1-2, 5-6 in the motor circuit (1). The motor brake contactor K4 (21) picks up via the K1 NO contact 13-14 (19) and the S36 control contact 11-12 (19), first opens contacts 71-72, 81-82 and 91-92 and then closes contacts 13-14, 23-24 and 33-34 (1).

The motor drive mechanism M1 starts running in a clockwise direction. The motor running clockwise consequently has a power take-off shaft (203) turning clockwise (viewed from the top).

The K1 and K4 are self-holding via contacts 43-44 (24) of the motor contactor K1, contacts 21-22 (26) of the step-by-step contactor K5 and the contacts 11-12 (26) of the limit switch S8.

Taking over step-by-step switching: After approx. 1.8 revolutions of the drive shaft (203), step-by-step switching is taken over by the direction of rotation contact S11 (23) (**Figure 8b**), by closing the contacts 13-14 (23).

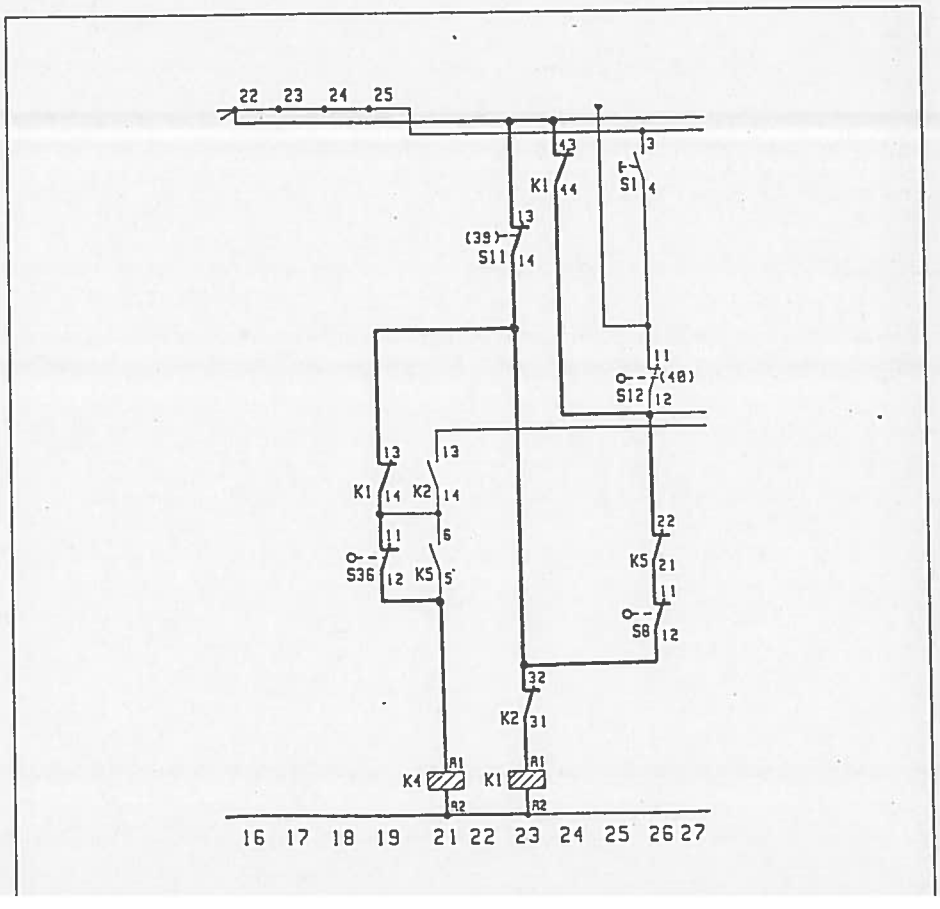
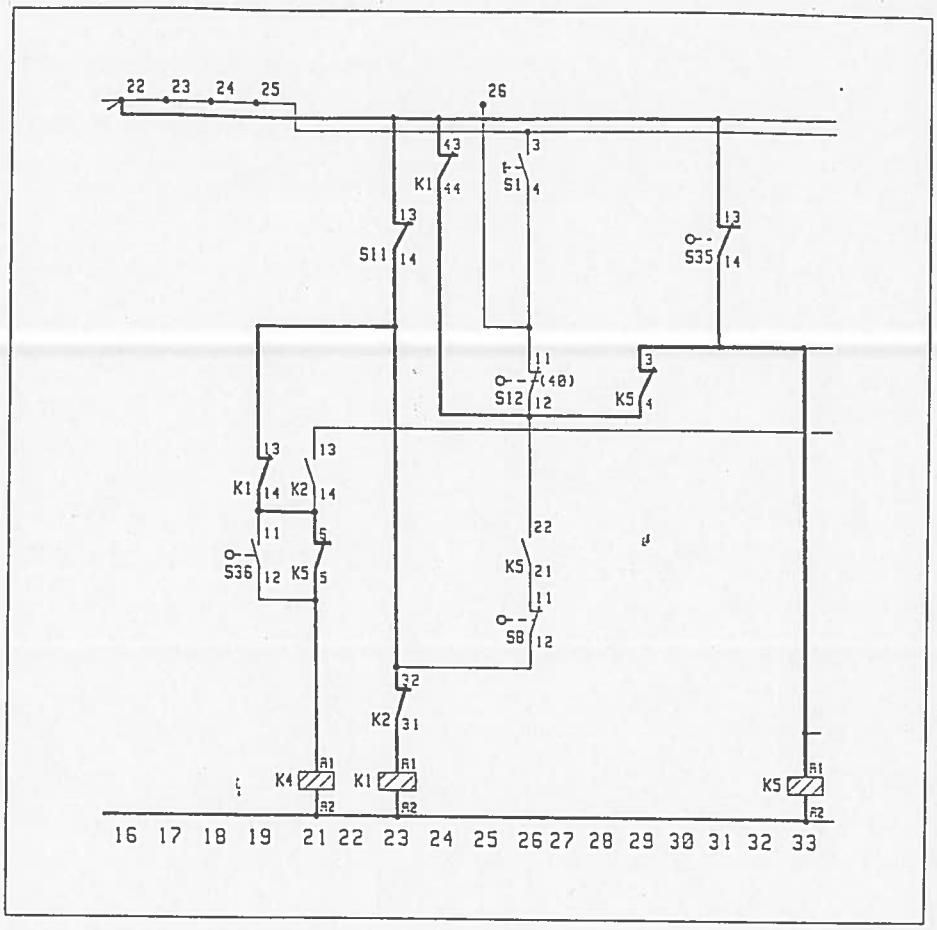


Figure 8b Step-by-step switching taken over by the mechanically controlled

Figure 8c Control circuit for controlling steps



After approx. 2.4 revolutions of the power take-off shaft (203), the control contact S35 closes contacts 13–14 (31) and thus applies voltage to K5 (33) (**Figure 8c**). As long as it is under voltage, K5 interrupts the self-holding and the drive cable of the motor contactor K1 (23), via contacts 21–22 (26). This guarantees the step-by-step operation controlled by the S11 contact 13–14 (23).

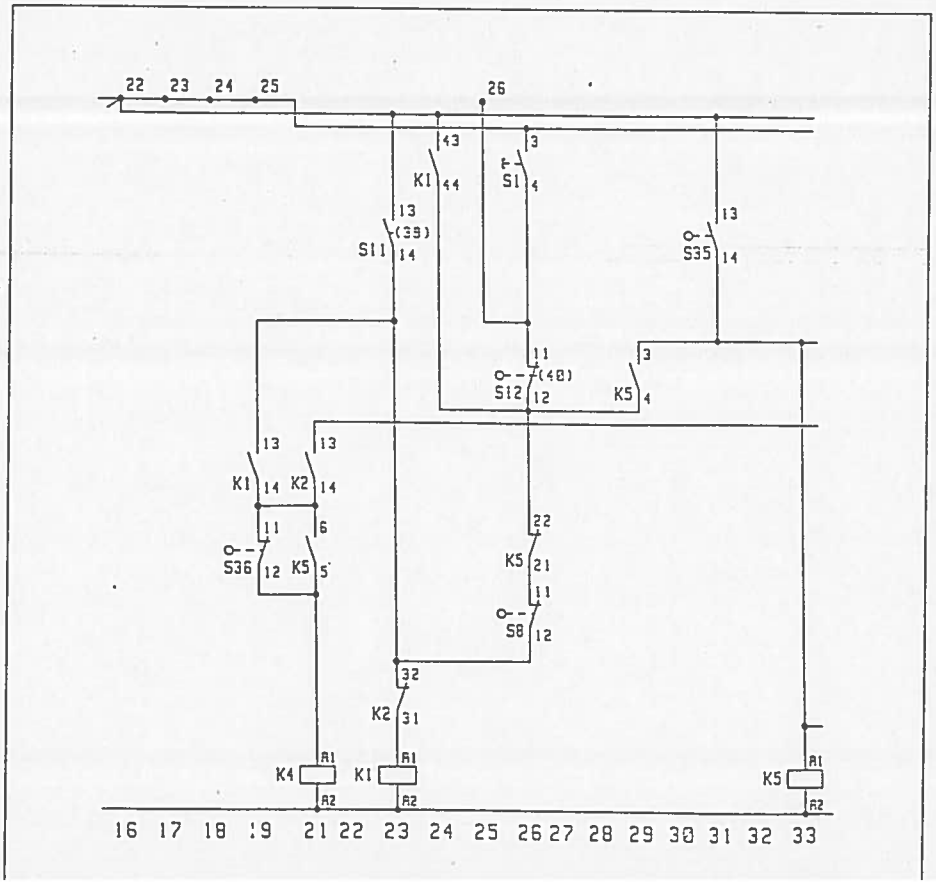
After approx. 2.6 revolutions of the power take-off shaft (203), the control contact S36 opens contacts 11–12 (19). The motor brake contactor K4 (21) remains under voltage via the K5 contacts 5–6 (21) parallel to it.

Contactor switch-off: At the end of the tap-change, the direction of rotation contact S11 opens in the "1" direction in (23) (**Figure 8d**). This de-energises the motor contactor K1 (23) and the motor brake contactor K4 (21). The K1 and K4 (1) NC contacts open so that the motor is now completely cut off from the mains.

Braking: If the motor brake contactors K3 and K4 drop out, the short-circuit brake circuit (2) at the motor terminals U, V, W is closed by the contacts 71–72, 81–82 and 91–92. The motor drive mechanism M1 is electrically braked.

The pulse for the next step can only be given when all controlling and operating elements are in the "off" position.

Supervising the step-by-step switching:
After approx. 2.6 revolutions of the power take-off shaft, the control contact S36 opens contacts 11–12 (19). If the step-by-step contactor K5 (33) has failed to pick up (e.g. on account of cable breakage), then its contacts 5–6 (21) are not closed. The motor brake contactor K4 (21) brings the drive to a halt, since the contacts 11–12 (19) and 5–6 (21) are switched



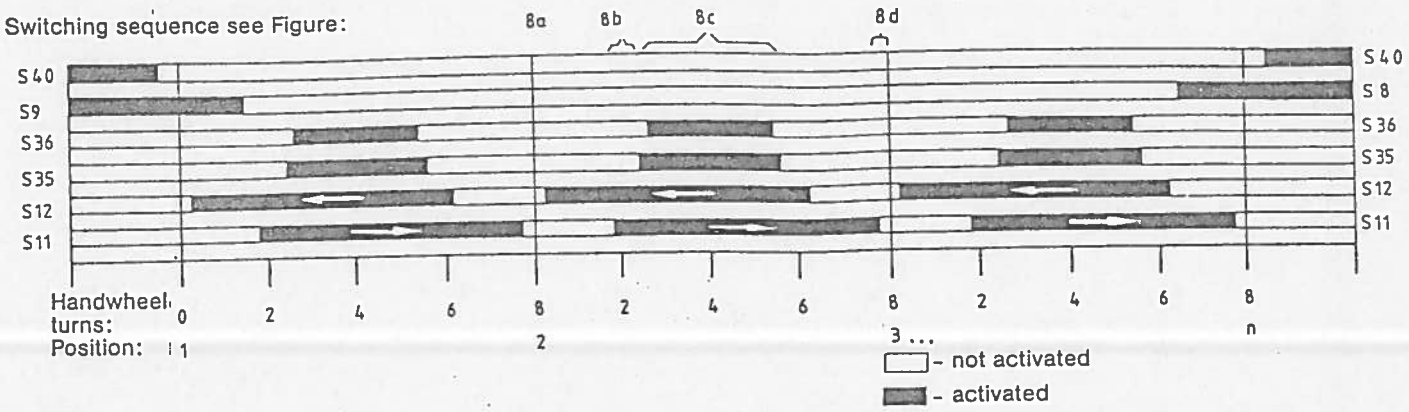


Figure 8e Switching sequence/step

in parallel and interrupt the operation of K4. It is no longer possible to operate the drive.
If, at the end of a step-by-step switching operation, the motor contactor K1 or K2 or the step-by-step contactor K5 fail to function properly, the drive is switched off as in undisturbed operation by opening of the S11 and/or S12 contacts 13-14 (23) or (40) respectively. But it can no longer be operated.

If the motor brake contactor K4 fails, the drive is switched off without braking at the step-switching end. This disturbance has no influence on the step switching operation.

Control in "n" direction:
Press button S2 (36) for step operation "n". Direction of operation contactor K2 (39) and thus also the motor brake contactor K4 (21) pick up. The motor drive mechanism M2 starts running counter-clockwise. After approx. 1.8 revolutions of the drive shaft (203), the direction of rotation contact S12 (40) takes over control. Otherwise control procedure is as shown in the flow chart analogously as for control in "1" direction.

4.2.2 Driving to end position "1" or "n"
After the direction of rotation contacts S11 (23) or S12 (40) have been operated, the limit switch S8 (26) or S9 (36) is opened by the end-position cam (312) already during movement from position "2" to "1" or from position "n-1" to "n". It is thus no longer possible to operate the motor contactor K1 and/or K2 and the motor brake contactor K4 beyond the end positions. As with the other tap-change operations, the drive is brought to a standstill when the direction of rotation contacts S11 (23) or S12 (40) open.

If the drive fails to come properly to a standstill on account of some fault, the security switches S40 (14, 15) trigger the motor protection switch Q1 after the end position has been overrun. This happens after not more than 2 revolutions of the power take-off shaft (203). The drive can no longer be operated electrically.

If the end position is overrun during manual operation, the electric limit switch is not operative, but after not more than 2.5 revolutions of the power take-off shaft (203), blocking will be performed mechanically. Before then, if the control voltage is on, the motor protection switch will be released electrically.

4.2.3 Voltage failure
If a voltage failure occurs during a tap change and then returns, the following applies:

As long as the direction of rotation contacts S11 and S12 are not operated, no automatic restart occurs. The drive can be restarted in any direction via S1 (26) or S2 (36). If operated in the direction contrary to the foregoing, the drive overruns the starting position up to the adjacent higher or lower position. If S11 (23) or S12 (40) has already been operated after approx. 1.8 revolutions of the power take-off shaft (203), then the drive will automatically restart in the original direction when power returns. As soon as the voltage returns, the NC contacts of S11 (39) or S12 (26) prevent the control pulse from becoming effective in the opposite direction.

If voltage failure occurs after S35 (24) has already reopened (after about 5.6 revolutions of the power take-off shaft (203)), the step-by-step contactor K5 cannot pick up again. The drive comes to a standstill only when it has reached the position after next. It cannot run beyond the respective end position, however (see 4.2.2).

4.2.4 Wrong phase sequence
(Operation must not be commenced when at end position "1" or "n"!)
After a pulse to "1" has been given via S1 (26), the motor contactor K1 and the motor brake contactor K4 pick up. The drive, however, starts moving in the opposite direction. The direction of rotation contact S12 (40) closes instead of the direction of rotation contact S11 (23). As soon as the step-by-step contactor K5 picks up via S35 (31), K1 ceases to hold itself because the K5 contact 21-22 is interrupted: K1 drops out. This temporarily interrupts the voltage at the motor brake contactor K4. Motor contactor K2 picks up via S12 (40), S11 and K1 (39), so that the drive runs back after K4 has picked up until S12 (40) opens and switches off the drive.

The drive operates in an analogous manner if an impulse to "n" is given via S2 (36).

4.3 De-energizing the motor drive mechanism
Attention! If the motor drive mechanism is to be de-energized completely, the incoming leads must carry no voltage.
Sections of the drive can be made free of voltage as follows:

Motor circuit: By releasing the motor protection switch Q1 directly or via the stop button S6 (13) from the control room.

Control circuit, heating and all lines looped in for monitoring purposes: By means of the respective circuit breakers - see the circuit diagram supplied.

The motor-protection switch can only be switched on in the drive.

4.4 Manual operation
Attention! Before the drive is operated manually, it must be de-energized by releasing the motor protection switch Q1. If the motor protection switch is on, the motor drive mechanism starts automatically.

The drive can be moved with the spokeless handwheel (606) over the drive housing. Eight turns are required to move one step.

The drive is in the correct tap position if the red indicator triangle (307) is aligned with the tap position mark (308) (**Figure 9**).

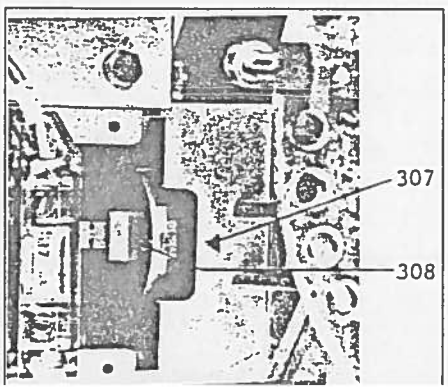


Figure 9 Motor drive mechanism is correctly placed at a tapping position

5.1 Installation

5.1.1 Transportation and storage
The motor drive mechanism can be transported in any position. Cable screws are closed. If stored for a longer period under humid conditions, the built-in heater, heating element E1, is to be put into operation.

5.1.2 Fitting into the transformer tank
Attention! Prior to installation check whether the number of tapping positions is the same on both motor drive mechanism and tap changer!

The motor drive mechanism is fastened in position with the four threaded bolts M10x50 (metric thread), four hexagonal nuts and four gaskets (see **Figure 10** for fitting dimensions). The console thickness must not exceed 22 mm. Care must be taken to ensure that the power take-off shaft (203) is aligned with the shaft to the bevel gear. Permissible alignment deviation (including installation tolerances) is 3° maximum (**Figure 10**), in the case of the cardan shaft 20° maximum.

5.1.3 Installation of the drive shaft and the bevel gear
See mounting instructions for on-load tap changers.

5.1.4 Coupling on-load tap changer and motor drive mechanism
The coupling position of the motor drive mechanism corresponds to the data in the tap-changer circuit drawing. Both tap changer and motor drive mechanism must be in coupling position. This position is indicated by a ▼ in the motor drive mechanism on the tap-position indicator disc (311) (**Figure 4**, page 6). This ▼ must be aligned with the indicator triangle ▲ (306). Furthermore, the tap-position indicator ▼ (307) must be aligned with the position indicator (308) (**Figure 9,** page 14).

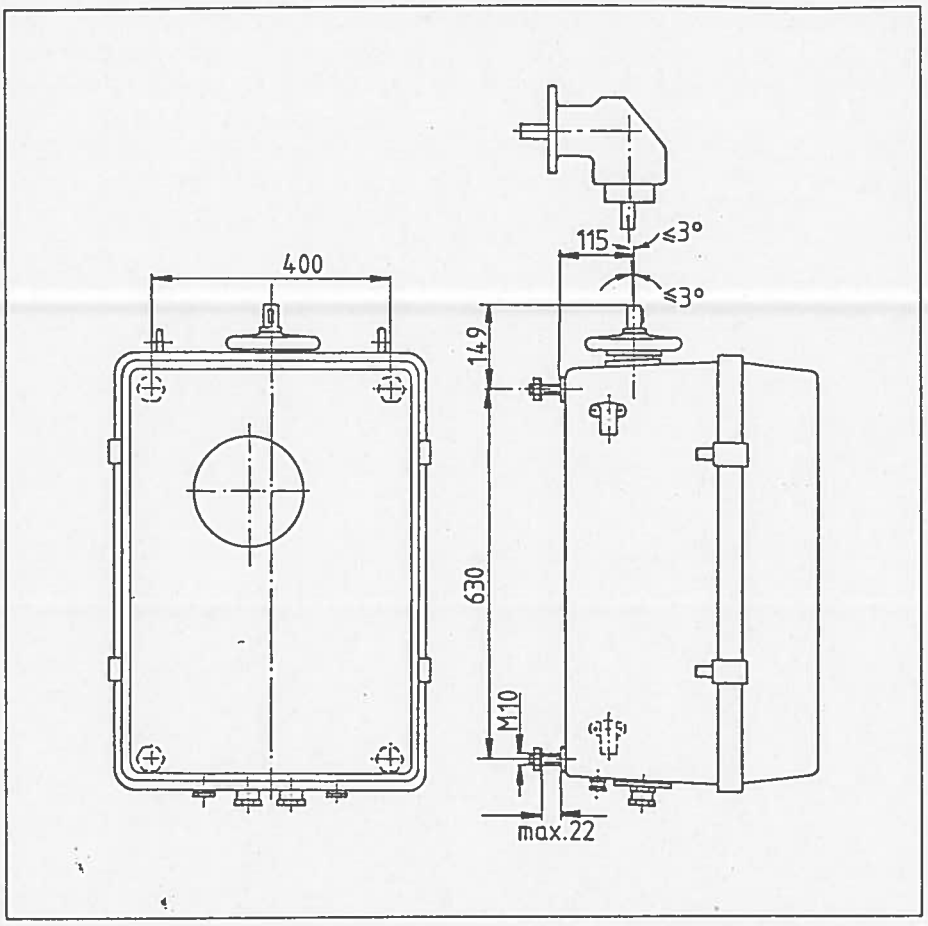


Figure 10 Mounting dimensions

Attention! After coupling, measure the transformer ratio when in each end position to check whether the motor drive mechanism and the on-load tap changer or selector switch have been properly coupled! For this work, movement to the end positions must be performed manually.

5.1.5 Preparing for electric operation

The electric cables to the motor drive mechanism are connected as shown in the circuit diagram delivered with it.

Before the motor protection switch Q1 is turned on, the drive mechanism should be in a position somewhere in the centre of the tapping range. It will be in correct position if the red indicator triangle (307) is standing opposite the tap position indicator (308) (**Figure 9**, page 14). The right-hand cam of the chock (204) should also be standing beneath the mark for the chock position (210) (**Figure 5**, page 7).

5.1.6 Setting the range limits

The two end-position cams (312) of the entire setting range (marked red) are fastened in the two holes of the tap-position indicator disc (313) with numbers indicating the highest and the lowest tapping position. The numbers are cast on the tap-position indicator disc (313) within the ring of holes.

A drive with "n" tapping positions will therefore have the two end-position cams (312) fastened in the holes numbered "1" and "n".

If other range limits have to be set subsequently, additional end-position cams can be added. For this, the following data is required:

a) FTNR (see rating plate in the motor drive mechanism)
b) Setting range limits before position "1" and/or "n"

Example:
Setting range not restricted:
$n_{\perp} = 1$, $n_{-} = 27$

The coupling position of the tap changer is also indicated by a ▼ at the position indicator in the input bearing or, in the case of selector switches, at the position indicator in the top section of the tap changer.

The diverter or selector switch must always reliably switch over before the motor drive mechanism comes to a standstill. This is achieved by setting the switch-over point of the diverter or selector switch clearly before the end of the step switching of the motor drive mechanism. As far as possible this difference must be the same in both directions.

Adjusting the on-load tap changer position:
After moving to any tapping position, the diverter or selector switch should switch in both directions very smoothly after 6.3 to 6.9 revolutions of the drive shaft (203) at the motor drive mechanism. To move one full step, eight handwheel turns are in chapter 2.4 of the operating instructions for on-load tap changers. Recoupling is performed by turning the drive shaft by 180° in each direction or, if cardan shafts are used, by 60° in each direction. This corresponds to 1/2 and 1/6 of a turn of a motor-drive handwheel (606), respectively.

Example:
The diverter or selector switch operates after six clockwise revolutions or seven counterclockwise turns of the handwheel. Half the difference between the number of revolutions (7-6)/2 = 1/2. The correction after decoupling is thus 1/2 a handwheel turn clockwise.

The drive shaft is then recoupled and the fastening screws tightened.

A limiting cam is to be fastened in the holes numbered 3 and 23.

5.2 Commissioning

5.2.1 Function tests
Before the motor drive mechanism is switched on, a check must be made to ensure that voltage, frequency and phase sequence of the voltage used correspond to the data specified on the rating plate and in the circuit diagram supplied with the motor drive.

5.2.1.1 Testing the step-by-step control
Press the S1 or S2 step-by-step control push-button. The drive mechanism must not move more than one step. Additional check: the push-button is held down. The drive mechanism must switch off at the next tap position all the same.

5.2.1.2 Testing the mechanical end stops
When the motor drive mechanism has reached an end position, it is operated in the same direction by means of the handwheel (606). Continue turning cautiously.

Attention! After about 1.8 turns of the wheel, the drive mechanism will automatically start running.

However, after not more than 2.5 turns, it will be brought to a standstill by the motor protection switch Q1 which is triggered by the security switch S40, and by the drive shaft (203) which is blocked by the chock (204). Blockage must always be performed by the chock (204), not by any blocking features which might be in the tap changer. If this is not the case, then the tap-changer position has not been properly set (chapter 5.1.4, page 15). Move back into position with the handwheel (606). Shift the chock (204) back into operating position. The chock can be felt to catch when it is in place. The indicator for the chock position (210) (**Figure 5**, page 7) is in front of the right-hand cam of the chock (204). The motor protection switch Q1 is switched on again. The test is performed in the same manner

5.2.1.3 Testing the limit switches S8 and S9
The motor drive mechanism is switched to one of the end positions. The motor must not start up again if it is operated further in the same direction, but it should start up again if operated in the opposite direction.

The test is performed in the same manner at the other end position.

5.2.2 Commissioning at the place of installation
Before the transformer is commissioned, the motor drive tests as set forth under section 5.2.1 are to be repeated. It must also be checked that the motor drive mechanism and the tap changer or selector switch are in the same position and have the same number of operating positions.

6.1 Remote control
The drive mechanism can be controlled from the control room by a pulse generated manually or automatically.

The motor protection switch Q1 is rendered ineffective by operating the stop push button S6. The motor protection switch can only be switched on again in the drive mechanism.

6.2 Local control
The drive mechanism can be controlled locally if the door (620) is open, and can be switched off with button "0" of the motor protection switch Q1.

6.3 Supervision of operation
We recommend the following routine checks at intervals of several months both during operation and even when the transformer is not in service:

1) A visuell check of the motor drive mechanism to ensure that the housing is waterproof and permits no water to seep in, proper functioning of the heater, satisfactory external condition of the components.
2) V-ribbed belt
   Some rubber may be abraded from the belt during operation. This does not affect its function.
3) The external shaft may need greasing. To prevent soiling, the door (620) must always be kept well shut during operation.

6.4 Maintenance
The following parts should be checked/work performed at intervals of one to two years when the transformer is not in service:

1) Door seals and lock
2) Housing air vents (621) cleaned
3) Heating
4) Terminal connections
5) Operation of the step-by-step control system, locally and from the control room
6) Electrical operation of the limit switches (see 5.2.1.3)
7) Mechanical check of end stops (see 5.2.1.2)

8) Multi-contact dial switch and tapping position indicator
9) If necessary, clean the motor-drive mecanism
10) If the drive housing is subject to severe mechanical vibrations, it is advisable to check the tightness of all screw fastenings and to retighten them if necessary
11) Check the condition of the V-ribbed belt
12) Check the tension of the V-ribbed belt (**Figure 11**). Any adjustments, with nut (206) (**Figure 5**, page 7)
13) If provided: automatic tap-position overrun, overrun with permanent contact, automatic return.

6.5 Inspection

This takes place at the same time as the inspection of the respective tap changer or selector switch. In addition to the checks described under 6.3 and 6.4 above, the following must be checked:

14) Function of the control circuits including monitoring circuits
15) The operating status of all components, particularly the contactors and push buttons.

We recommend to have inspections performed by service personnel from Trafo-Union or personnel trained by TU.

Responsible for southern Germany and all foreign countries:

Trafo-Union GmbH
Product Service Kirchheim
Hegelstr. 20
P.O.Box 1554
D-7312 Kirchheim (Teck)
Telephone (07021) 508-1
FAX (07021) 508-477/488
Telex 7021102 = TUK

Responsible for northern Germany:

Trafo-Union GmbH
Product Service Bochum
Cruismannstr. 48
D-4630 Bochum-Riemke
Telephone (0234) 531165
FAX (0234) 531165
Telex 825461

6.6 Faults

We recommend that Product Service Kirchheim be contacted whenever a fault occurs (see 6.5 above).

If single components such as contactors, push buttons, etc. break down, only original makes and types approved by Trafo-Union GmbH may be used as replacements.

The sequence of operations required if it becomes necessary to replace the V-ribbed belt (see **Figure 12**):

1) Always bring the drive mechanism into coupling position (see 5.1.4, page 15)
2) Switch off the motor protection switch Q1
3) Unscrew the nut (206) and tip the motor towards the centre of the housing
4) Remove two bayonet clips from the chock axle (205)
5) Pull the chock axle (205) to the left and suspend the chock (204) on the right-hand side. Then pull the chock axle (205) to the right and suspend the chock (204) on the left-hand side.

Figure 11 Checking the tension of the V-ribbed belt (207)

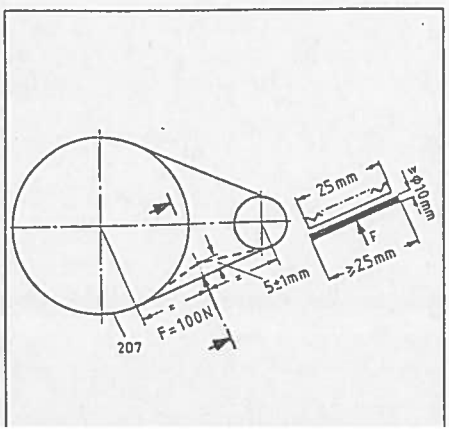
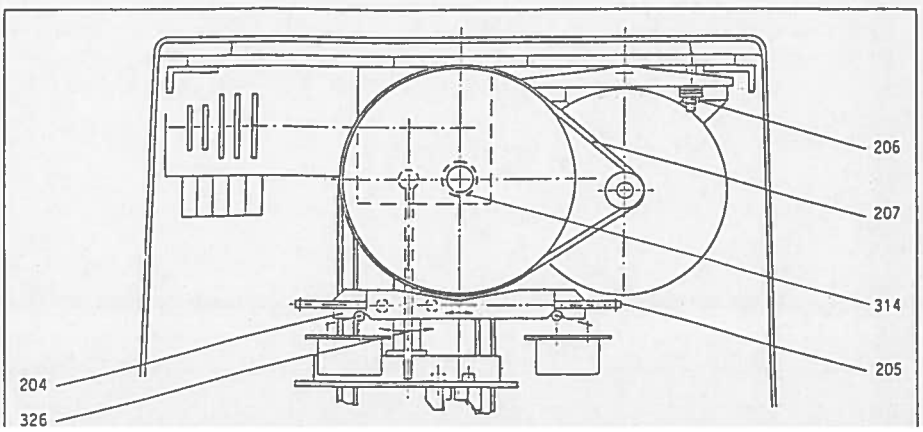


Figure 12 Changing the V-ribbed belt

204 Chock
205 Chock axle
206 Nut to tighten the belt
297 V-ribbed belt
314 Coupling
326 Chock lever



6) Move the chock on the right-hand side downwards, then shift to the left together with the chock lever (326) and remove the chock by tilting.
7) Remove the coupling (314). Loosen the top cylinder screw with hexagonal socket head wrench SW 5, and unscrew the bottom cylinder screw.
8) Change the V-ribbed belt (207).
9) Remount the coupling (314).
10) Insert the chock (204) by tilting.
11) The chock lever (326) must be between the two cams of the chock (204).
12) Insert the chock axle (205) and secure it as described in (4) and (6) but reversing the sequence).
13) Shift the chock (204) until the right-hand cam of this chock is beneath the indicator of the chock position (210). The chock can be felt to catch in place. The security switches S40 are not operated.
14) Tighten the nut (206) until the V-ribbed belt is sufficiently tensioned (**Figure 11**, page 17).
15) Check the position of the motor drive mechanism and on-load tap changer or selector switch (see 5.1.4, page 15).
16) Commission (see 5.2, page 16).

7.1 Special circuits

7.1.1 Local/remote changeover switch S46
7.1.2 Heating element changeover switch S15
7.1.3 Automatic overrun of certain tapping positions, overrun contact dial switch S23
7.1.4 Overrunning any tapping position by means of continuous contact, push buttons S51, S52
7.1.5 Return to tapping position "n" by means of a brief control pulse, push button S51

7.2 Special electrical accessories

7.2.1 General
Electrical equipment is available for following special voltages:
Motor circuit: see **Table 2** (page 3)
(standard 380/220 V, 50 Hz)
Control circuit:
Rated voltage:
110–380 V a.c., 50/60 Hz
60–200 V d.c.
(standard: 220 V a.c., 50 Hz)
Control circuit with overrun multi-contact dial switch:
Rated voltage:
110–240 V, 50/60 Hz
60–200 V d.c.
(standard: 220 V, 50 Hz)
Monitoring circuit:
Rated voltage up to 220 V
Heating circuit and light:
Rated voltage:
110 V, 220 V
(standard 220 V)
The accessories listed below cannot all be accommodated in the motor drive mechanism simultaneously.

7.2.2 Socket outlet with earthing contact X1
7.2.3 Hand lamp E4 with door contact S14
7.2.4 Progress lamp H... in motor drive mechanism, for supervision and checking purposes
7.2.5 Start-up capacitor C1
Operating capacitor C2
(C1 and C2 for single-phase operation with three-phase motor)
7.2.6 Miniature circuit breakers F... (one or two-pole)
the available mounting rail length: 55 mm
7.2.7 Auxiliary contactor K7..., as additional control contactor
7.2.8 Time-lag relay K11 for monitoring operating time
7.2.9 A second contact range plate S17, S23 (each with one contact range)
7.2.10 Emergency heater socket X9
7.2.11 Base plate for cable insertion by means of plugs and/or cable end boxes, plus compression glands in the drive cabinet
7.2.12 Encoding device U1
7.2.13 Thermostat B1 (set at 20 °C) for heating element E1
7.2.14 Push buttons S1, S2 for step-by-step control, and contact S5 to stop the drive, in the door of the motor drive mechanism.

7.3 Mechanical accessories

7.3.1 Crank with motor interlock S7 (52 revolutions per step)
7.3.2 Mechanical stroke counter
7.3.3 Summation counter
7.3.4 Door made to take a padlock
7.3.5 Resettable minimum/maximum indicator
7.3.6 Circuit diagram as a plate in the housing door

7.4 Equipment for special climatic conditions

7.4.1 Model protected against sand and dust storms, IP 55 to IEC 144 and DIN 40050
7.4.2 Model for aggressive environments with outside ventilation

Further information on request.

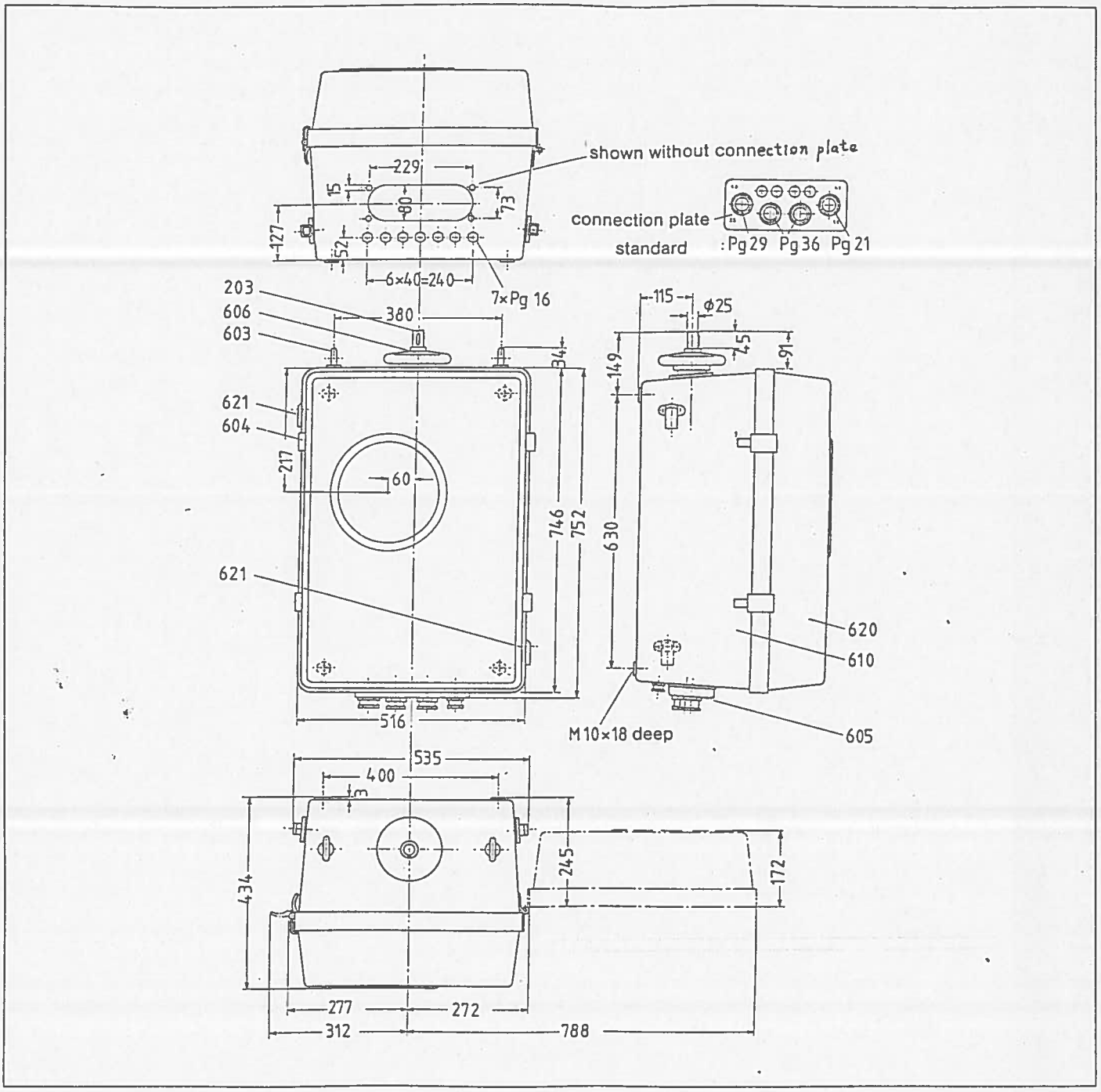


Figure 13 Dimension drawing of the MA-E/4

203 Power take-off shaft
603 2 transportation eye-bolts
604 Door lock
605 Connection plate
606 Handwheel
610 Cabinet
620 Door
621 Air vents

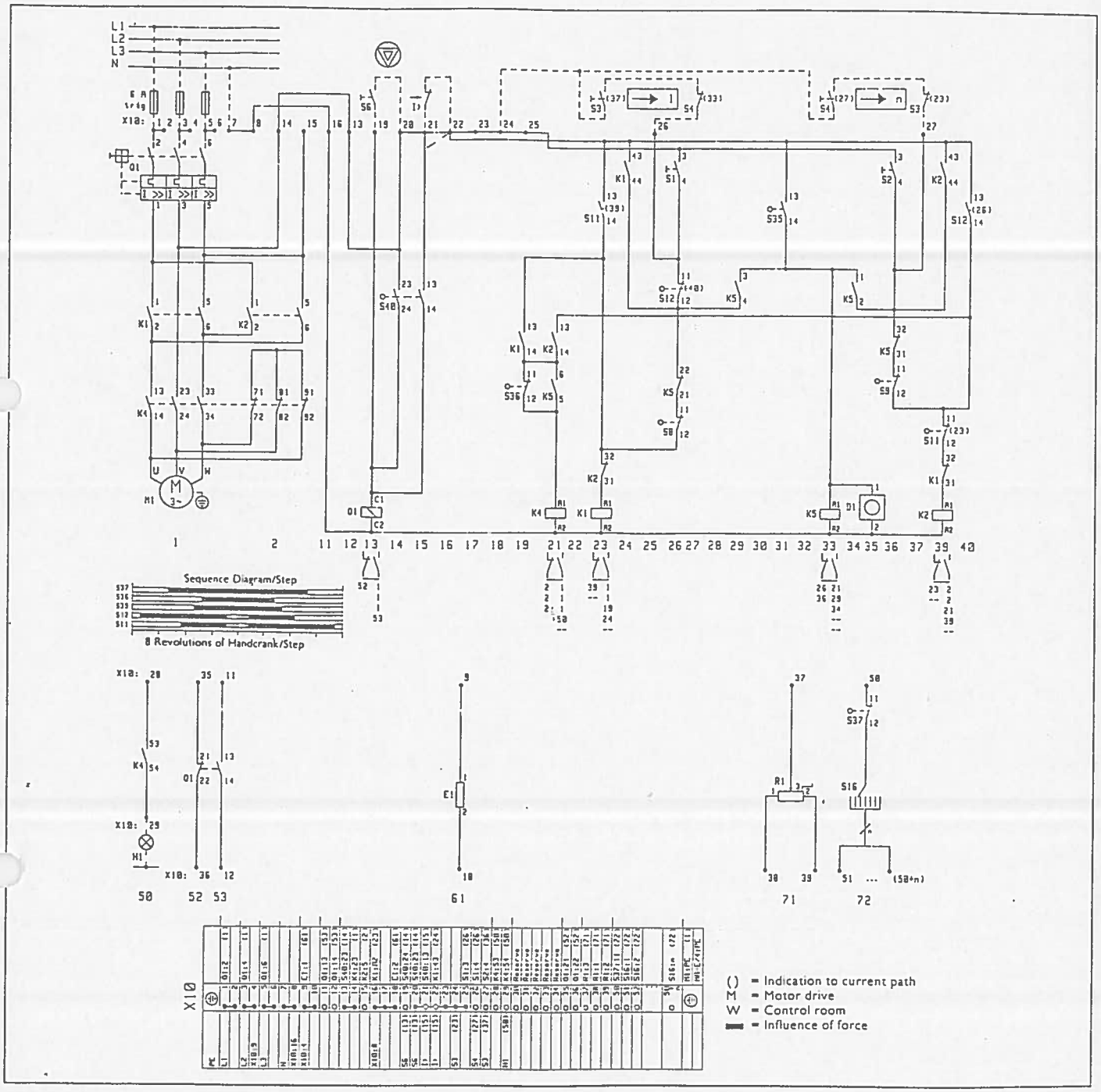


Figure 14 Circuit diagram

E1	*Heating element*	*M*	*Q1*	*Motor protection switch*	*M*	*S8–9*	*Limit switch*	*M*
H1	*Progress lamp*	*W*	*R1*	*Resistance tele-transmitter*	*M*	*S11–12*	*Direction of rotation contact*	*M*
K1–2	*Motor contactor*	*M*	*S1–2*	*Push button*		*S16*	*Multi-contact dial switch*	*M*
K4	*Motor brake contactor*	*M*		*for step-by-step control*	*M*	*S35–36*	*Control contact*	*M*
K5	*Step-by-step contactor*	*M*	*S3–4*	*Push button*		*S37*	*Auxiliary contact*	*M*
M1	*Driving motor*	*M*		*for step-by-step control*	*W*	*S40*	*Security switch*	*M*
D1	*Pulse counter*	*M*	*S6*	*Push button to stop the drive*	*W*	*X10*	*Terminal strip*	*M*

1. Electrical equipment to 3.2

D1 Pulse counter
Make: Veeder Root,
Model: 7517
for voltage rating, see drive

E1 Heating element
wire resistance
Make: Draloric,
Model: GWS 100 SS
220 V, a.c./d.c., 970 ohms

K1, K2 Motor contact

K5 Step-by-step contactor
Make: Siemens in each case,
Model: 3 TB 4017-OA
for voltage rating, see drive

K4 Motor brake contactor
Make: Siemens
Model: 3 TH 8355-OA
for voltage rating, see drive

M1 Drive motor for three-phase and single-phase current
Make: Dietz
Model: DR 80 B/8 4D
0.25 kW
for voltage rating, see drive
d.c. current
Make: Stützel, Model GM
0.25 kW
for voltage rating, see drive

Q1 Motor protection switch
Make: Siemens
Model: 3VE1 010
for release current range
see drive
Auxiliary switch with
1 NO, 1 NC contact
Operating current release
Model: 3VX4 220
for voltage rating, see drive

R1 Resistance tele-transmitter
metal film resistor
Make: Draloric
Model: SMA 0411,
TK 100 ± 1%

S1, S2 Push buttons for step-by-step control
Make: Starkstrom
Switching element,
model DG11
Push button, model D1A1S
Coupling, model Z11

S8, S9 Limit switches

S35, S36 Control contacts

S40 Security switch
Make: Schaltbau in all cases
Model: S 826 a

S11, S12 Direction of rotation contact
Make: Schaltbau
Model: S 826 f

S16 Multi-contact dial switch
Make: TU
Model to FTNR

S37 Auxiliary contact
Make: Schaltbau
Model: S 800 a

X10 Terminal strip
Terminal block
Make: WAGO
(without screws)
Model 282-101
(motor circuit)
Model 280-101
(control circuit)
Model 282-107
(protective conductor)

2. Supplementary electrical equipment to 7.2

B1 Thermostat
Make: Eberle
Model: 172153521
Range: 0 to +30 °C

C1 Starting capacitor

C2 Operating capacitor
Make and model:
see drive

E1 Heating element
Wire resistance
Make: Draloric
Model: GWS 100 SS
110 V a.c./d.c., 500 ohms

E4 Hand lamp
Make: Rademacher
Model: 111801

F1 ... Miniature circuit breaker
a.c./d.c.
Make: BBC
Model: see drive
plus auxiliary switch
Model: see drive

H2 Signal lamp
Make: Jautz
24 V order no. 440
110-130 V, 220 V
order no. 449A

K7-K10 Auxiliary contactor
Make: Siemens
Model: 3 TB 4017-OA
(45 mm wide)
Make: Siemens
Model: 3 TH 8355-OA
(55 mm wide)

K11 Time-lag relay,
delayed response
Time set: see drive
Make: Pilz
Model: PA-1SU/8/13/220 V
Ws 1UZ FBM
U_B 24 V a.c. to 240 V a.c.
40 to 60 Hz
24 V d.c. to 48 V d.c.

Trafo-Union GmbH
Katzwanger Strasse 150
D-8500 Nürnberg 40
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(0911) 434-0
Ttx 911856 = TUN

S1, S2	Push button for step-by-step control Make: Siemens Switching element Model: 3SB1400-OA Operating element Model: 3SB1120-OAB00 Protective cap Model: 3SB1902-1AK
S5	Push button to stop the drive Make: Siemens Switching element Model: 3SB1400-OA Operating element Model: 3SB1120-OAC00 Protective cap Model: 3SB1902-1AK
S7	Motor interlock Make: Schaltbau Model: S 826 a
S14	Door contact Make: Elan Model: SEK 110
S15	Heating element change-over switch
S46	Local/remote change-over switch Notching switch in each case Make: Starkstrom Switching element, Model DG11 Selector, Model D1G2S Coupling Model Z11
S17, S23	Multi-contact dial switch Make: TU Design to FTNR
S51, S52	Push button for overrun control Make: Starkstrom Switching element, Model DG11 Push button, Model D1A1S Coupling, Model Z11
U1	Encoding device Make: see drive
X9	Emergency heater socket Make: Schaltbau Model: Stv XIII/Dst 2 m long Plug for emergency heater Make: Schaltbau Model: Stv XIII/Sfb with earthed contact
X10	Terminal strip Make: Phönix (with screws) Model: UK 10 (motor circuit) UK 4 (control circuit) UKK 3 (multi-contact dial switch) USLKG 10 (protective earth conductor)

1. FOREWORD

TROUBLESOME MAINTENANCE AND CHECK WORKS ARE ALMOST FREE FOR THE LATEST POWER TRANSFORMER BUT IT IS RECOMMENDED TO PERFORM MAINTENANCE AND CHECK IN ORDER TO PREVENT TROUBLE OF THE TRANSFORMER.

THE CHECK PERIOD DEPENDS UPON IMPORTANCE IN THE TRANSFORMER SYSTEM AND ENVIRONMENTS OF AN INSTALLATION SITE OR WEATHER.

THE FOLLOWING COVERS MAINTENANCE AND CHECK OF THE OIL-IMMERSED TRANSFORMER IN NORMAL WORKING CONDITION.

2. DAILY CHECK

Check the following points in daily patrol

Check point	Check Item	Description/Procedure	Criterion or Remdey
Temperature	Ambient temperature. oil temperature. Winding temperature. (if thermometric device attached for winding).	Monitor, and recording the temperature degrees	
Oil	Oil level. Oil leak.		1) When oil leaks from a gasket, retighten it. If the leak persists, renew the gasket. 2) When oil leaks from weld zones, contact "TATUNG CO LTD" TAIPEI, TAIWAN R.O.C.

Check point	Check Item		Description/Procedure	Criterion or Remedy
Accessary	Cooling device	Abnormal noise and vibration	Abnormal noise and/or vibration of cooling fan and oil feed pump	Renew bearings when there is abnormal noise from bearings.
		Oil leak	Oil leak from cooler valve, radiator, oil feed pump, etc.	When oil leak is noted, contact "TATUNG CO LTD" TAIPEI, TAIWAN R.O.C.
		Abnormal operation	Check cooling fan and oil feed pump for abnormal operation. Check oil flowmeters for abnormal to operation.	
		Dust deposition	Dust much deposited on radiator.	
	On-load tap-changer		Be in accordance with related instruction manual.	
	Oil presser-vation system	Dehydrating breather (Cell-seal or diaphragm constant pre-ssure type or gas-oil-seal type)	Check dehydrating agent for wetness.	When dehydrating agent turns pale purple, recycle dehydrating agent by drying.

Check point	Check Item	Description/Procedure	Criterion or Remedy
Accessory (cont'd)	Bushing	1) Cracks. breakage, fouling of pipes 2) Overheat of terminals 3) Oil level and oil leak.	
	Pressure release device	1) Pressure release plate cracks. 2) Symptom of oil spouting. 3) Gas and/or oil leak 4) Elongation or cut-off of safety pin.	
Miscellaneous	Abnormal exciting noise and vibration		

3. REGULAR INSPECTION

In addition to daily checks, regularly check the following points.

Check point	Check Item	Period	Description/Procedure	Criterion or Remedy
Winding	Insulation resistance measurement (including bushing)	2 or 3 years	1) Use 1000V megger. 2) Measure the resistance across windings and groundings.	Be in accordance with Fig.1 and Table 1.
Insulation oil	Di-electric voltage or breakdown voltage of electric strength	2 or 3 years	Be in accordance with procedure and devices provided in AS 1767-1975, IEC 296(1972), BS148-1972.	40 KV/2.5mm or more .... Acceptable, if unacceptable, remove impurities by filtering.
	Acidity after oxidation value measurement	2 or 3 years		1) Less than o.2mg KOH/g... Acceptable. 2) 0.2mg KOH/g to 0.5mg KOH/g : Recycle as soon as possible. 3) More than 0.5mg KOH/g : Instantly recycle.

Check Point	Check Item	Period	Description/Procedure	Criterion or Remedy
Insulation oil (cont'd)	Analysis of gases in oil	Less then 300 MVA 1 year	Less than 300 MVA Measure volume of gases soluble in oil just before operation start, 1 month, 6 months and 1 year after operation start and after that, every year. Use gas chromatograph.	Volume (m) of combustible gases in 100 m of oil 1) Below 0.08:acceptable 2) More than 0.08 and below 0.5:Follow to investigate composition and increase rate of the gases every 6 months. 3) More than 0.5: Measure volume of the gases soluble in oil in short period and strictly follow to investigate composition and increase rate. Also perform internal check taking opportunity. In the cases of 2) and 3), contact "TATUNG CO LTD" TAIPEI, TAIWAN, R.O.C.

Note : 1. Combustible gases soluble in oil include hydrogen, carbon monoxide, methane, ethane, ethylene, acetylene, etc.

Check Point	Check Item	Period	Description/Procedure	Cirterion or Remedy
Insulation oil (cont'd)				2. When a soluble rate of acethylene gas is more than 0.01 m/100 m of oil, follow to investigate the composition and increasing rate in short period in accordance with (3) even if total volume of combustible gases is 0.5m, and perform internal check taking opportunity. 3. When analyzed data change greatly from component pattern, contact "TATUNG CO LTD" TAIPEI, TAIWAN R.O.C.
Accessory	On-load tap changer		Be in accordance with related instruction manual	
	No-voltage tap changer	1 year	During check, gently changeover tap.	Check to be sure that tap can smoothly be changed over with light cricks.

Check Point	Check Item		Period	Description/Procedure	Criterion or Remedy
Accessory	Oil preser-vation system	Nitrogen-sealed-tank type	2 or 3 years	Measure purity of nitrogen.	More than 97% : Acceptable
		Gas-oil-seal type	2 or 3 year	Measure purity of nitrogen.	More than 97% : Acceptable
		Cell-seal (diaphragm) constant pressure type		Check dehydrating breather and oil level gauge.	
Accessory (cont'd)	Bushing	General	2 or 3 years	1) Pipe cracks 2) Contamination incl-uding saline content 3) Oil leak 4) Rust formation 5) Insulation resistance (when separted from winding)	1) When contamination is excessive, clean by cloth containing ammonium or carbon tetrachloride and neutralize with neutralizer. After that, wash in fresh water and wipe off with dry cloth. 2) When terminals loose, retighten them.

Check Point	Check Item		Period	Description/Procedure	Criterion or Remedy
Accessory (cont'd)	Cooler	Radiator or cooling fan	3 years	1) Check fan motor bearings. 2) Insulation resistance (during check of bearings)	Insulation resistance : More than 1 MΩ
		Unit cooler (for general)	3 years	1) Check fan motor bearings. 2) Insulation resistance.	
			1 year	3) Check cooling pipe and tube seat for contamination.	Clean root of cooling pipe using hot-water cleaner.
			3 years		Clean root of cooling pipe applying hot water and recoat the pipe.
	Mechanical Protective ralay		2 or 3 years	Operation tests of gas detector relay, sudden oil pressure relay, sudden gas pressure relay contacts.	

Check Point	Check Item	Period	Description/Procedure	Criterion or Remedy
Accessory (cont'd)	Pressure release device	2 or 3 years	Visually check for appearance in details. 1) Pressure release plate cracks. 2) Symptom of oil spouting. 3) Gas and/or oil leak. 4) Elongation or breakage of safety pin.	Take following remedies if required. 1) Renew the plate. 2) Renew safety pin. 3) Renew gaskets. 4) Retighten screws.
	Protective control circuit	2 or 3 years	1) Operating tests of relays pressure, oil flow, oil level, pressure release device, dial thermometer, cooler power supply, etc. 2) Start/stop tests of cooler fan and pump. Check for control sequence. Check NFB solenoid contactor for operation. 3) Insulation resistance measurement of wiring. 4) Visually check wiring in details.	Insulation resistance : More than 1 MΩ
	Dial thermometer	1 year	1) Check for external construction.	

Check Point	Check Item	Period	Description/Procedure	Criterion or Remedy
Accessory (cont'd)	Dial thermometer	3 years	2) Check for operating and insulation resistance.	Insulation resistance : More than 1 MΩ
	Mercury or alcohol thermometer	1 year	1) External construction check. 2) Tolerance test compare to with standard thermometer.	When excessive error is noted in tolerance, renew bar thermometer.
	Winding temperature equipment	1 year	1) External construction check.	
		3 years or when error is noted in thermometer indication	2) Check for operation and insulation resistance . Indicating thermometer . Current transformer . Heater and resistor . Insulation resistance	Insulation resistance: More than 1 MΩ
	Thermal resistance bulb	1 year	1) External construction check. 2) Wiring connection check	

Check Point	Check Item	Period	Description/Procedure	Criterion or Remedy
Accessory (cont'd)	Thermal resistance bulb	3 years	3) Indicated temperature and characteristic checks . Indicated temperature . Resistance value	In comparison of difference in indications between thermal resistance bulb and dial thermometer in the early time of transformer operation start with difference in indications in check, difference must be less than 3°C. Insulation resistance : More than 1 MΩ
	Thermal resistance bulb (cont'd)		. Insulation resistance	
	Dial oil level gauge	1 year	1) External construction check	
		3 years	2) Operation* and insulation resistance checks. . Switch operation . Check float and pointer for operation and microswitch for operation . Insulation resistance	The check marked with asterisk(*) must be performed when internal check is required. Insulation resistance : More than 1 MΩ
	Dehydrating breather	In replacing dehydrating agent	1) Construction check	

Check Point	Check Item	Period	Description/Procedure	Criterion or Remedy
Accessory (cont'd)	Dehydrating breather	1 year	2) Breating action check 3) Oil cup oil level	. Oil level must reach red line. . Tip of breathing cylinder must be submerged into oil.
	Dehydrating breather (cont'd)			
	Gasket	1 year	Check bolts and nuts for looseness.	Retighten them if required. Note: When gasket oil airtight chamber is removed renew gasket.

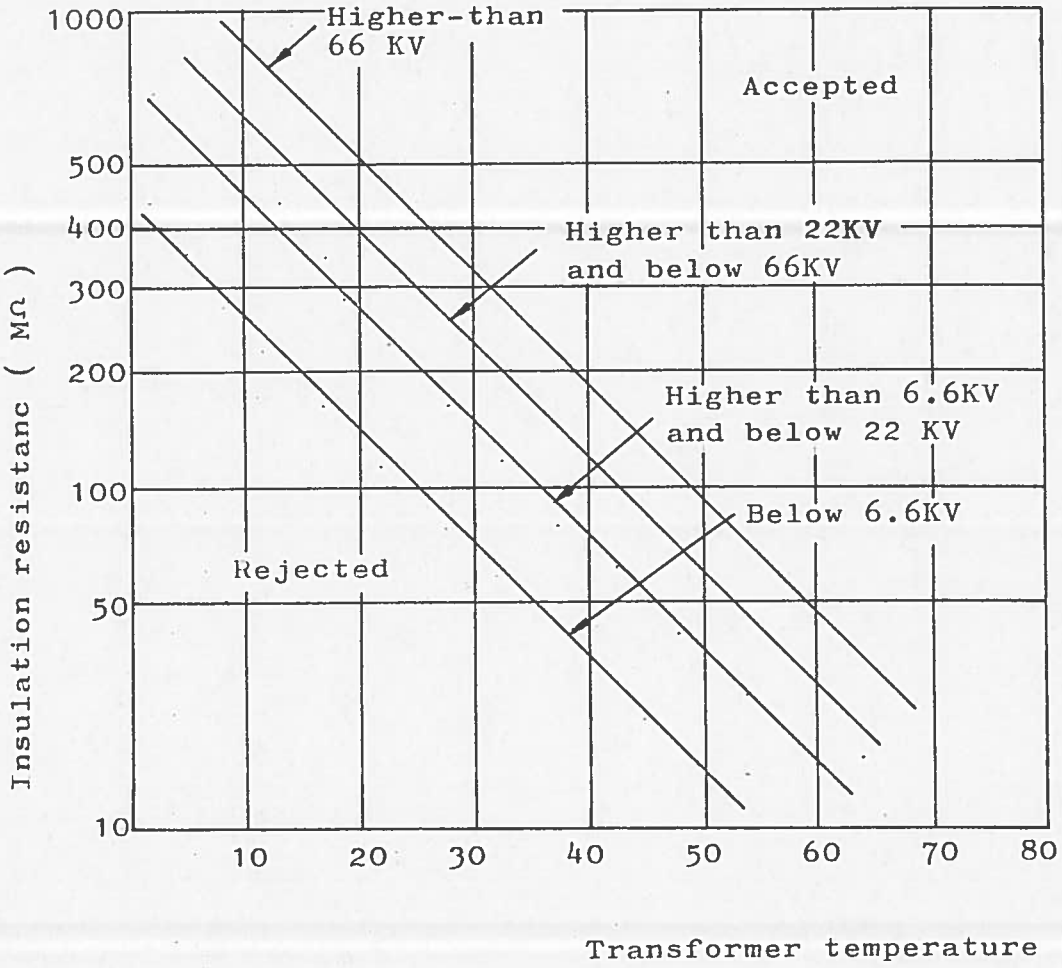

Fig. 1 Allowable Insulation Resistance of Transformer

(1,000 V Megger Used)

Table 1 Large power Oil-Immersed Transformer (New) Insulation Resistance

Temperature (C)	Insulation Resistance (MΩ)
20	2,000
30	1,200
40	800
50	500
60	300
70	200

Note : The above-shown table shall apply to any winding of higher than 3 KV.

4. REPLACEMENT STANDARD

When any abnormal condition is noted, must be renewed in accordance with the following standards.

Parts		Replacement Period
Oil pump	Ball type	When abnormal noise is produced from one pump in working of longer than 10 years, renew all the bearings taking an opportunity of stop.
	Plane type	When abnormal noise is noted in one pump in working of longer than 5, renew all the bearings taking an opportunity of stop.
Cooling fan	Non-lubrication type	When abnormal noise is noted in one cooling fan in working of longer than 3 years, renew all the bearings taking an opportunity of stop.
	Lubrication type	When abnormal noise is noted in one cooling fan in working of longer than 10 years, renew all the bearings.

Parts		Replacement Period
Vibration-proof joint	Rubber type	In working of longer than 10 years, renew all the joints in accordance with condition.
	Metal type	Generally, 30 years or so.
Oil-tight gasket		In working of longer than 10 years, renew all the gaskets in accordance with condition.
Pressure release Plate and safety pin of main unit		Those, when checked, must be renewed in accordance with condition.
Measuring instruments and relays		(1) Dial thermometer and pressure gauge: Renew them about once per 10 years. (2) Thermal resistance bulb, oil flowmeter, oil level gauge and mechanical protective relay: Renew them about once per 30 years.
Components in motor control for on-load tap-changer		See the instruction manual for the on-load tap selector.

5. PRECAUTIONS

When the transformer is maintained or operated, observe following points.

Item	Description
General	. A protective device such as an arrestor must always be installed to the winding terminals of any transformer for which insulation class is specified. . When any transformer is operated, its temperature must not exceed a value for which is provided in AS-C61, ANSI-C57.12.00, IEC-76-2, BS-171 or the oil-immersed transformer operation rule. . Keep off the air bushing during operation. . Do not completely stop the pump during operation. . Do not control the bleeder plug in principle during operation.

Item	Description
General (cont'd)	. When each end valve of the oil system is closed, release pressure rise of closing sections using the bleeder plug.
Oil preservation system	. Operation must not be performed with the coupling pipe valve closed.
Dial oil level gauge	Do not adjust its pointer.
Dial thermometer	. Do not bend or pull the guide pipe. . Do not remove the cover without a valid reason.
Mercury or alcohol thermometer	When a spare thermometer is stored or renewed, do not fall it.
Drain oil plug	After operation, completely tighten the plug and cap.
Pressure gauge	This is an air-tight type in construction. Do not remove the cover.

This instruction manual covers the important points of installation.

1. RECEIVING INSPECTION

A transformer upon arrival at site should carefully be inspected as following points.

Check the gas pressure. The gas pressure is changed in proportion to the gas temperature as shown in Fig. 1. The initial gas pressure and temperature are shown on the tank wall. If the pressure changing deviates significantly from the graph in Fig. 1, the transformer may have breathed moist air. Check that the dew point of gas is equal to or lower than the following values.

Gas temperature (^{o}C)	Dew point (^{o}C)
0	-35
10	-30
20	-25
30	-15

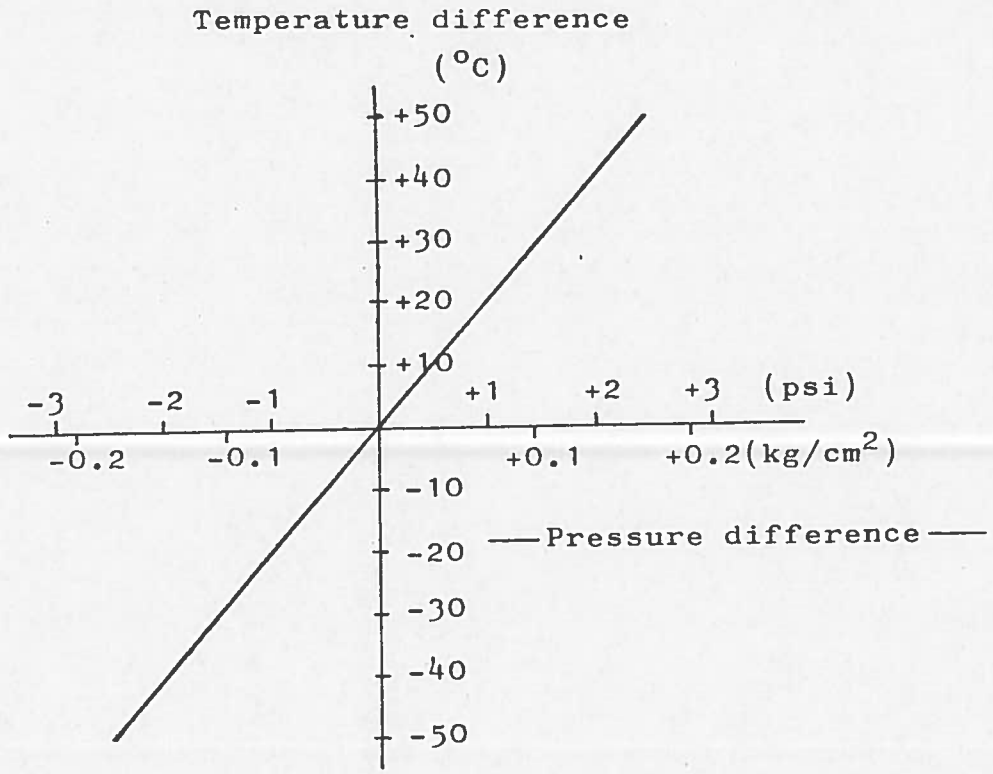

Fig. 1

Note: "Temp. difference" signifies gas temperature at the time of arrival at site minus gas temperature at dispatch.
"Press. difference" means the gas pressure at the time of arrival at site minus gas pressure at dispatch.

2. INSTALLATION

2.1 General

2.1.1 Application of gasket

(a) Remove throughly all the rust and sticking matters from the gasket surface of flanges and grooves until the base metal is exposed.

(b) Before using the new gasket, supply the seal and rust proof paste to the both side of gasket.

2.1.2 Internal connection

Use the torque wrenches for tightening bolts of terminals and bare conductors. The required torque for each size bolt are shown in Table 1.

Table 1

Bolt size	Torque	
	Kg - cm	Lbs - ich.
M6	50 ± 10 %	44 ± 10 %
M8	120 ± 10 %	104 ± 10 %
M10	250 ± 10 %	217 ± 10 %
M12	600 ± 10 %	522 ± 10 %
M16	1000 ± 10 %	870 ± 10 %

2.1.3 Permissible exposed time of core and coils

While working on the transformer with the cover open such as internal inspection, bushing installation, internal connection and so on, the core and coils will absorb moisture due to be exposed to atmosphere.

Therefore the exposed time of core and coils should be limited with in a specified time as shown in Fig. 2.

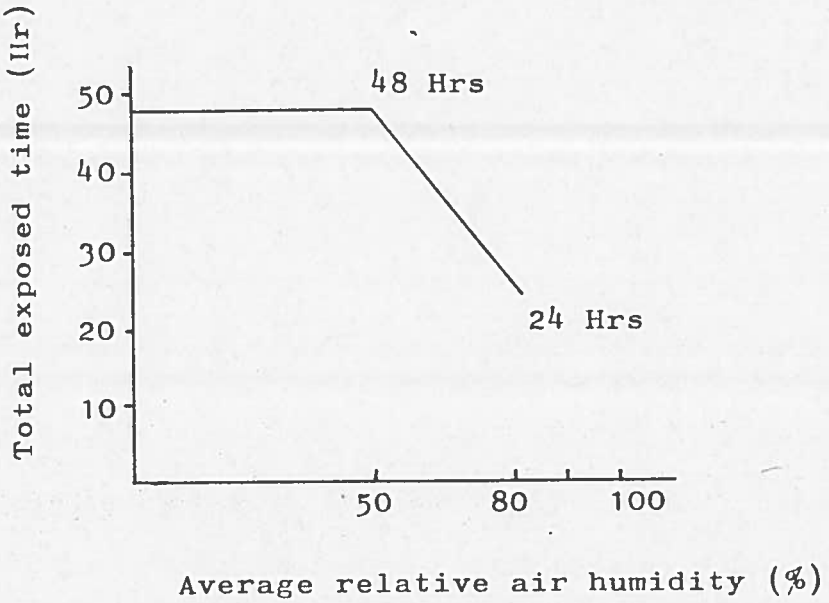

Fig. 2

2.2 Tank assembly

2.2.1 Setting main tank

(a) Place the transformer base so that each centering mark of the transformer base coincides with the center line of the foundation.

(b) Set each main tank on the transformer base coincides with the guide of the main tank.

2.2.2 Internal inspection

(a) Check the coil end insulation and coil clamping devices fitted between coils and yokes such as studs, blocks and wedges.

(b) Check the lead supports, insulation studs and nuts. If there is any stud or nut loose, tighten carefully.
Do not apply excessive torque on insulation studs and nuts.

(c) Check the appearance of bare leads and their bolted joints.

2.2.3 Assembling of transformer tank, OLTC tank and conservator.

(a) Fit the transformer tank, the OLTC tank and the conservator.

(b) Remove the temporary connecting pipe for pressure equilibrium fitted between the OLTC tank and the OLTC compartment. After removing the pipe, fit the blank covers on its openings. The blank cover is supplied separately.

(c) Fill the transformer tank, the OLTC tank and conservator with oil up to the oil level indicator indicates 50 percents.

(d) Bolted the tank flanges, transformer base and the brace.

2.3 Assembling radiators or coolers

(a) Remove the blank covers for each radiator or cooler and be sure not to leave the desiccant in the radiator or cooler attached to either of the blank covers.

(b) Remove the spring brace from the oil pumps and drain oil out from the oil pumps.

(c) Keep the butterfly valves closed until ready to start oil filling under vacuum.

(d) Fit the radiators or coolers on the main tank.

2.4 Mounting bushings and internal connections

To carry out internal work such as mounting bushings and internal lead connection, drain oil out as required replacing with dry air.

(a) Mount the all bushings on the bushing pockets.

(b) Connect the all internal leads to the bushings.

2.5 Internal inspections for OLTC tank

Check the appearance of on-load tap changer and leads. Confirm that the moving contacts of tap selector are on the approximate center of the fixed tap.

2.6 Connecting handle operating mechanism

(a) Connect the driving shafts between the handle operating mechanism and the bevel gear unit.

(b) Unlock the operating handle and confirm that the tap changing operation can be performed smoothly, by observing the torque required to turn the operating handle in each direction and in each position.

If the equipment was assembled correctly, each position will be at the center of a high torque region.

2.7 Oil filling under vacuum

The vacuum oil filling should be carried out in accordance with the instructions. HIE-0172-82.

(a) In order to prevent the deformation of the driving shafts during evacuating, the driving shafts should be uncoupled.

(b) Drain oil out from the transformer completely replacing with dry air.

(c) Transformer tank should simultaneously be evacuated with the on-load tap changer (OLTC) compartment through its conservator. Never operate the OLTC while the OLTC compartment and transformer tank in which the OLTC is installed are evacuated.

2.8 Oil filling for OLTC

The oil filling for the OLTC compartment should be carried out in accordance with the instructions HR-64016-60-1.

LONG-TERM STORAGE FOR TRANSFORMER OR REACTOR

When the transformer is to be placed in storage, it is recommended that it be set in its permanent location with all accessories installed. In this case, the transformer should be maintained during storage as though it was in service, in accordance with a relevant instructions attached.

If this is not convenient, all suppries such as transformer main tank, coolers, bushings, accessories, etc. should be stored as follows. It is recommended to execute exactly following instructions, to avoid any trouble on the erection work or on the operation in future.

1. Receiving inspection

Immediately upon arrival at site, the transformer main tank and all the parts should be inspected in accordance with the instructions for installation.

2. Location and condition of temporary installation and/or storing

2.1 Transformer main tank and big, heavy parts

(1) Transformer main tank and such big, heavy parts as shown the location "OUT DOOR" in the following table may be installed and stored outdoors.

(2) Provide a strong, level foundation, and place the transformer main tank on it. The foundation should have enough strength against the transformer total weight.

(3) The heavy parts such as on-load tap changer tank, bushings, etc. should be placed and stored on the strong, level ground, and should be covered with tarpaulins. Lay a sleeper if necessary.

(4) Select the location where air can ventilate freely, and keep the transformer main tank and the parts at well drainage.

(5) Other storing conditions to be established for the individual parts are shown in the following table.

2.2 Coolers, . oil pipes and accessories

(1) Coolers, radiators, and such accessories as shown the location "INDOOR" in the following table should be unpacked and stored in the dry, well ventilated room.

(2) Other storing conditions to be established for the individual parts are shown in the following table.

3. Maintenance

In order to prevent trouble of the transformer and parts, perform maintenance and check periodically during the storage period.

The maintenance and the check period for a part depends on environment, weather, location, storing condition, importance and construction of the part etc. The following covers maintenance and check in normal condition. For the individual transformers and parts, plan maintenance and check referring to the following, and maintain them in good quality.

(1) Check outside of all the parts for damage and rusting once a month.

(2) Check inside of all such parts as were filled with nitrogen gas and have no pressure gauge, for rusting once a year. Immediately after each checking, seal and fill with nitrogen gas again.

(3) Other check points and criterions necessary for individual parts are shown in the following table.

Check oil levels and check for oil leak in daily patrol.

Note 1. The oil level will drop below the air cell type conservator if the ambient temperature drops to minus 20°C or below. If this happens, it will be necessary to add oil.

Note 2. Watch the gas pressure once a week for a month and once a month for subsequent period.

Before installing the parts after a long-term storage, check as follows:

a. Determine the dew point of the gas remaining in the part.

The dew point of gas should be equal to or lower than the values in the following table.

Gas temperature (°C)	Dew point (°C)
0	-35
10	-30
20	-25
30	-15

b. If the dew point is not satisfactory, the parts must be dried.

Note 3. Test after the first few days, six months, one year, and then yearly. If unacceptable, remove impurities by filtering.

(4) Don't put the transformer in service after a long-term storage without making sure that the insulation and insulating oil are dry.

Parts	Location		Storing conditions (to be established)	Check points	Criterion
	Outdoor	Indoor			
Transformer (or reactor) main tank Main tank with on-load tap changer Conservator	○		1. Oil-filled storage Put the conservator with dehydrating breather in operation and fill with oil. If the on-load tap changer (LTC) is set in the main tank, take the same steps on the LTC compartment. 2. The main tank should be grounded.	1. Oil level	0～100 % (Refer to Note 1)
				2. Oil leak	No evidence
				3. Dielectric strength of oil (Refer to Note 3)	50 kV/2.5 mm ga or better
On-load tap changer tank Cable junction box Such compartment having an insulation in it.	○		1. Gas-filled storage Connect the temporary connecting pipe between the LTC tank and LTC compartment. Seal and fill with dry nitrogen gas, and fit the pressure gauge.	1. Gas pressure (Refer to Note 2)	0.05～0.2 kg/cm
Bushing Lightning arrester	○		1. Do not lay down toward sideways. Keep such inclination as was set for transportation. 2. Attach a protective cover around the porcelain.	1. Oil leak	No evidence

Parts	Location		Storing conditions (to be established)	Check points	Criterion
	Outdoor	Indoor			
Unit cooler Radiator with or without cooling fan Pressure relief vent Oil pipe		○	1. Certainly seal and fill with nitrogen gas.		
Oil Pump		○	1. Fill with oil	1. Oil leak	No evidence
Insulating materials e.g. Insulating paper Press board		○	1. Keep immersed in oil	1. Oil leak	Ditto
				2. Dielectric strength of oil (Refer to Note 3)	50 kV/2.5 mm gap or better
Accessories e.g. Valve, Relay, Wiring conduit, Wiring, Terminal box, Gasket		○	1. Keep the accessories in a container with a dehydrating agent.		
Motor driven operating mechanism		○	1. Put the dehydrating agent into the motor driven operating mechanism. 2. Seal the wiring outlet with a rubber tape.		

Parts	Location		Storing conditions (to be established)	Check points	Criterion
	Outdoor	Indoor			
Fan Driving shaft Gear box On-load oil-purifier etc.		○			

TATUNG CO.

Power Transformer
15/20/25/28MVA
Instruction Manual

G.P.A. P.O. No.B800-01137

MACHECHE, TUMOLI, TAMULING

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