INDEX TO SECTION 5
800V DC METAL-ENCLOSED SWITCHGEAR

INSTRUCTION BOOK FOR
800 VOLT DC METAL ENCLOSED SWITCHGEAR

for

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

Lansdowne Way Substation
Windham Lane Substation
Mount Vernon Square Substation
U Street Substation

WMATA Contract No. 1Z1049
SSE-9

Instruction Manuals

Description	Mfr.	Publication	Tab
DESCRIPTION OF OPERATION	CPC	4482-A51 4482-A52	1
DC CIRCUIT BREAKER	PAMCO	P388T	2
SHUNT	CROMPTON	U/S920 S	3
DC AMMETERS DC VOLTMETERS	CROMPTON	U/S700 PG. 19-22	4
HIGH RESISTANCE GROUND RELAY	GEC	R-5443PB	5
LOCKOUT RELAY	ELECTRO SWITCH	LOR-1	6
UNDERVOLTAGE RELAY	P&B	13C207	7
INDICATING LIGHT	GE	GEH-3500B	8
OVERCURRENT RELAY	GEC	R-5257A	9
ISOLATION TRANSDUCER	SCI COL	PG.11 6271A PG. 45-50	10
WATT TRANSDUCER	SCI COL	YD-08736-001-N	11
TELEMEGAWATTMETER	OSI	CAD-1941	12
CONTACTOR	WEST	IL-17071	13
METER RELAY	LFE	955-242:2242	14
AUXILIARY RELAY	C&S	C880.2	15
TIMER	ATC	319 TDR SS	16
CAM TIMER	ATC	324 CAMTIME	17
LOAD MEASURE RESISTOR	HUBBELL	DWG. A69309	18
OVERCURRENT RELAY	BBC	IB 7.5.1.7-1	19
THERMOSTAT	DAYTON	5S1421	20
HEATER	CHROMALOX	CAT.PG.180	21
ISOLATION TRANSFORMER	ITI	CAT.SECT.6 PG.5	22

Instruction Manuals (cont'd)

Description	Mfr.	Publication	Tab
1000V FUSE	GOULD	CP-50M-388 PG.136-137	23
(FUTURE)			24 25

CATHODE CIRCUIT BREAKER
CONTROL CIRCUIT
Description of Operation

I. Breaker in the Connected Position

A. General - Breaker In The Connected Position. The cathode circuit breaker control can be set to either the remote or local operating mode by a control switch (43/R, 43/L). The protective trip and lockout functions are operable any time the breaker is in the connected position independent of the position of the remote 43R/local 43L control switch.

B. Remote Mode - In the remote position the local close/open control switch is disabled and an automatic close circuit is enabled. The automatic close circuit will cause the cathode breaker to close when (1) the lockout relay (86D) is in the reset position; (2) the rectifier feeder breaker is in the connected position (52HR/a); (3) the rectifier feeder breaker is closed (52R/a); and (4) the rectifier enclosure doors are closed (33x).

C. Local Mode - In the local position the automatic close circuit is blacked and the local close/open control switch is enabled. The breaker can be manually closed with the close control switch (72CS/L) only after the same four conditions for automatic close listed above are satisfied. The breaker can be opened by the open control switch (72CS/T).

II. Breaker in the Test Position

A. Test Mode - When the breaker is in the test position both the automatic close, the protective trip, and lockout functions are by-passed. The breaker can be closed or opened by placing the remote/local control switch in local and operating the local breaker close/open control switch. Note the breaker can be closed regardless of the status of rectifier feeder breaker or the rectifier enclosure doors.

CRO FILMED

WN BY
AB

DATE
3/25/88

MATERIAL

SCALE

CONTROLLED POWER CORP.
211 WETMORE AVE., S.E. • P.O. BOX 533
MASSILLON, OHIO 44646

TITLE
Cathode Circuit Breaker Control Circuit

NO	BY	DATE	DESCRIPTION

REVISIONS

DWG. NO. 4482-A51

D.C. FEEDER BREAKER CONTROL SCHEME
Description of Operation

When the D.C. Feeder Breakers are in the Test or connected (On-Line) position, the auto reclose circuit is engaged and closing will only occur after the load measuring equipment has determined that the system is free of shorts or overloads. Activation of the auto reclose circuit can be initiated by the manual control switch, Device 172CS, or by tripping of the circuit when in operation. Tripping will occur immediately upon receiving a trip signal from either a protective device or the manual control switch.

The load measuring scheme described here in detects system conditions for both stub connected and tie connected systems. The load measuring scheme employs two measuring relays referred to as the load measuring relay, Device 182, and the voltage compensating relay, Device 183.

The load measuring relay, Device 182, is an API Type 503X Meter Relay scaled 0-1 ohm, with a left-hand (A) contact.

The voltage compensating relay, Device 183, is an API Type 503X Meter Relay scaled 0-800V and having left-hand (A) and right-hand (B) contact. The left-hand contact (A), normally closed, will be set such that anything over 12 volts across the relay will open its contacts (A). The right-hand contact (B) will be set such that anything over 450 volts across the relay will close its contact. Both contacts are adjustable if different settings are required.

The load measuring resistor is set at 15 ohms to give 47A at 700V. The resistor is designed to carry 47A with one minute "ON" and 30 minutes "OFF". When the circuit breaker is open, this resistance is connected between the positive bus bar and the feeder cable end. The flow of current will be inversely proportional to the sum of the load measuring resistance, i.e. 15 ohms and resistance between the positive contact wire running and negative rails. The load measuring relay, Device 182, is connected such that it will measure the voltage produced by the current flowing between the resistance between the contact wire and running rails and indicates the current that would flow if the circuit breaker is closed.

The load measuring relay also measures any negative return volt rise which may be present in the system. This negative return volt rise appear due to the bonding of the two running rails, and of the "INBOUND" and "OUTBOUND" tracks together. Traffic on the system produces return current which flows back down the running rail of the feeder where the circuit breaker is open. The value of the negative volt rise depends on the nature of bonding, traffic on the system and the distance between substations. This voltage drop rise is compensated for by adjustment of the lower contact of the 183 which will not allow the feeder breaker to close under abnormal conditions.

MICRO FILMED

BY
AB

DATE
3/25/88

MATERIAL

SCALE

CONTROLLED POWER CORP.
211 WETMORE AVE. S.E. • P.O. BOX 533
MASSILLON, OHIO 44646

TITLE D.C. Feeder Breaker Control Scheme

NO	BY	DATE	DESCRIPTION

REVISIONS

DWG. NO. 4482-A52 Sheet 1 of 3

"This scheme is based on the fact that the voltage drop in the negative rails will normally be less than a certain value and anything higher than this will be of a transient nature. The value of this voltage will depend on track resistance, distance between substations and traffic conditions. It is expected to be about 12 volts."

When the feeder breaker is in the test or connected position, operation of the control switch, Device 172CS, will energize the latching relay, Device 201X (Operated). A contact on Device 201X will complete the circuit to the auto close relay timer, Device 186 and 102 will commence counting time.

The voltage compensating relay, Device 183, continuously measures the voltage between the feeder end and the negative rail.

"For the stub condition assume the voltage across the voltage compensating relay, 183 will be zero or below the 12 volt setting." The "A" contact on Device 183 will remain closed. When cam contact No. 2 on Device 102 closes after three seconds, contactor, Device 129 will be energized and sealed in by its contact No. 3 and the 15 ohms resistor will be connected between the positive bus bar and feeder cable. The flow of current is limited by this load resistor and the load or fault on the track. The load measuring relay, Device 182, will measure the voltage across the positive contact wire and the negative track. If this voltage exceeds the setting of the "B" contact on Device 182, it will close the "B" contact which will energize the auxiliary closing relay, Device 172/Z.

When the cam contact No. 3 on Device 102 operates, a contact on Device 172/Z will seal in the Device 172/Z. Another contact on Device 172/Z will energize the closing coil which in turn will close the circuit breaker. The anti-pumping relay device deenergizes once the circuit breaker is closed or operates trip free. If in the sub condition, the voltage across the voltage measuring relay is in excess of 12 volts, which may be due to excessive negative volt rise, then its "A" contact will be opened. This will prevent the contactor, Device 129, from becoming energized when the can contact No. 2 on Device 102 closes. Closure of the circuit breaker will not take place. A further load measurement will continue after an interval of 14 seconds because Device 186 will remain energized, and the Device 102 will continue to rotate. It is expected that the negative voltage rise will be below 12 volt during one of the load measurements, in which case the circuit breaker will close. The time-delay contacts on Device 186 is set at three times the cycle time of Device 102. If the circuit breaker does not close during the checking period, the Device 186 will close its time-delay contacts which will reset the Device 201 and the load measuring circuit.

If a successful closing of the circuit breaker take place in the first closing attempt, the supply to Device 186 is maintained by the cam contact No. 1 on Device 102, and this in turn keeps the Device 102 running. As Device 102 runs it opens first cam contact No. 2 then No. 3 and No. 1 thereby resetting Device 129. About eight seconds after cam contact No. 2 on Device 102 opens, cam contact No. 1 opens which deenergizes Device 186 and 102.

In the tie condition, if the voltage across the voltage compensating relay, Device 183, is above the setting 450 volts, this "B" contact will be closed which will energize the auxiliary closing relay, Device 172/Z, when the cam contacts No. 2 and No.1 2 on Device 102 are closed. This will close the circuit breaker as described before.

P388T
INSTRUCTION BOOK
REV. 0

HIGH SPEED D.C. SWITCHGEAR TYPE HSN(P)

PAMCO

Power
Apparatus
Mfg. Co.

CONTENTS

ILLUSTRATIONS

1. FOREWARD

The type HSN (P) high speed circuit-breakers are designed to perform satisfactorily under the arduous conditions imposed by a modern D.C. Rapid Transit System. The large capacity silicon rectifiers used in these systems demand a highly rated circuit-breaker capable of high speed operation to limit the rapidly rising fault currents without producing dangerous overvoltages.

When given the maintenace stated in this instruction book, the type HSN (P) circuit-breaker will continue operating satisfactorily for many years. It should be appreciated that a high speed circuit-breaker is a machine doing extremely heavy work. The moving contact is given a rapid acceleration and is brought to rest even more rapidly, therefore the breaker is very strongly built. Its function is so extremely important that it requires periodic examinations, cleaning and lubrication like any other piece of machinery.

1.1 STANDARD SPECIFICATIONS

The type HSN (P) high speed circuit-breaker is constructed in accordance with the following standards:

B.S. 4752

Specification for switchgear and controlgear for voltages up to and including 1,000 volts A.C. and 1,200 volts D.C.

I.E.C. 157

Low voltage switchgear and controlgear.

A.N.S.I. C37.14

Low voltage D.C. power circuit-breakers.

2. HANDLING

2.1 SHIPMENT

Breakers are usually shipped in their housings with the breakers racked home into the service position. They may be in individual units, or several units together, depending upon site handling facilities and suitable natural separating points in the busbars. They are shipped on wooden pallets with the units firmly banded to prevent movement.

2.2 CHECKING THE EQUIPMENT ON ARRIVAL

Check the equipment against the dispatch notes and the check list as soon as the equipment arrives. If damage is evident, determine the extent and cause of the damage immediately. Should the damage have occurred during transit, inform the carrier and together with him, make out a report. This is essential, where a claim for damage is to be made.

2.3 UNPACKING

Dismantle the crate from the top, leaving the units standing on the base. Lift the units from there, with breakers in the housings, using the lifting beams provided.

Note:

Single units have four lifting eyes screwed into angle brackets in the center section of the cubicle. Multiple units have a lifting beam, with lifting eyes bolted onto the same angles. After lifting, the eyes on single units or the beams on the multiple units must be removed.

When the breakers have been removed from the crate, the breakers can be withdrawn from the housings if required. See later instructions under OPERATION - Section 8.

3. STORAGE

If the breakers cannot be installed immediately following delivery, store them in a clean dry area. Should the switchgear accidentally become damp, dry it as soon as possible using forced warm air.

4. DESCRIPTION

Each type HSN (P) breaker unit consists of a wheeled truck and housing. The circuit breaker is mounted on the truck together with its mechanism, controls and closing and tripping devices. The housing contains busbars, cable connections, isolating contacts together with control relays and metering equipment.

It is normal for a number of units to be installed side by side to form a switchboard. Housings which make up a switchboard are bolted together, while trucks remain independent, and be readily inserted or withdrawn without disturbing the others. All trucks of a similar current rating are fully interchangeable.

There are three positions for the trucks, SERVICE, TEST and WITHDRAWN. In the "service" position, the truck is fully inserted into the housing and all the circuits are completed. In the "test" position, the truck is withdrawn to the full extent of the rack, but not pulled further. In this position, the main contacts are disconnected, but the control circuits remain intact so that test operations are possible. In the ""withdrawn" position, the truck has been pulled clear of the housing and the circuit breaker is completely disconnected.

Interlocks prevent the trucks being withdrawn from or inserted into the "service" position with the circuit breakers closed. Safety shutters automatically shield the main contacts when the circuit-breaker is removed.

Control switches and indicator lamps for the circuit-breaker are mounted on the front panel. The control selector switch selects either local or remote control. The trip and close switch trips the breaker direct and either closes the breaker direct or initiates the load measuring auto-reclose sequence coil. The closing operation is powered by the closing solenoid 18 which also charges the opening springs 6 (S778A). The breaker can be closed by hand using the manual closing handle provided, but this is intended for emergency and maintenance operations only.

When the breaker is tripped, it opens extremely rapidly under the action of the opening springs 6 (S778A). To ensure high speed operation the main moving contacts are designed to have a low mass. They are constructed of lightweight alloy with silver contact tips.

The silver cadmium oxide tip 56 (S778B) fitted to the moving arcing contact 57 is given a lead over all the silver tips 55 fitted to the main moving contacts 35, so that it makes before and breaks after them, thus acting as an auxiliary arcing contact.

A fixed arcing contact assembly (S778E) is fitted above the top fixed contacts (See Illustration S778A). The two spring-loaded arcing contacts 78 (S778E), make contact with the moving arcing contact 57 when the breaker is closed. The arcing contacts 78 are adjusted so that they make first on breaker closing and open last on breaker opening.

The arc is, therefore, transferred to the arcing contacts 57, and on to the arc runners 1 and 2 (S778A).

The arc chute 166 (S778N) is comprised of a number of verticle steel plates arranged around and over the arc runners in such a way that the arc is drawn into the stack of steel plates, and is broken into a number of small arcs which are cooled and extinguished as they move rapidly towards the top of the plates.

The breaker is equipped with an air puffer, mounted between the top and bottom main contacts and operated by the breaker mechanism. This is completely automatic and assists with the control of small arcs, produced by the interruption of low value currents, in either direction, which may otherwise tend to linger on the main arcing contacts.

Operator tripping is performed electrically by the shunt trip coil 138 or manually by pressing the hand trip knob 131 on the front panels (S778L).

Automatic tripping is initiated by one of the several possible protection devices e.g. the instantaneous bi-directional overload device, the low set uni-directional reverse current device, the shunt trip or undervoltage release.

Protection relays and instruments are mounted on the hinged door fitted to the housing immediately above the front panel of the truck. Behind this hinged door are accommodated the terminals and buswires.

Further relays are accommodated at the rear of the housing. Shunts, transducers or current transformers are mounted on the connections at the cable side of the circuit.

Load measuring resistors are mounted on the top of the housings.

5. INSTALLATION

Switchboards are often too long to be shipped in one piece and they are therefore split into portions of up to four units, which are of a suitable size and weight to permit them to be readily handled without damage.

Before commencing installation, ensure that the substation layout and foundation plan are available.

According to the customer's requirements the switchboards are supplied for solid grounding or to be grounded through a resistance and monitoring device. In the latter case, the switchboard stands on an insulated foundation and the units may be insulated from each other. The installation procedure will vary according to these circumstances.

5.1 DIRECTLY GROUNDED SWITCHBOARD

5.1.1 Lay a suitable concrete foundation, that is, one that is flat and level. It must also contain cable holes and fixing pockets in the correct positions as shown on the foundation plan.

5.1.2 Mark out the front line of the switchboard on the floor. The position of this will be determined by the positions of the fixing pockets.

5.1.3 Having removed the trucks from the housings, position the switchboard with its front edge on the line marked out.

5.1.4 Where necessary use shims under the base to make the switchboard plumb and level.

5.1.5 Link the portions of the switchboard together using the nut, bolts and washers supplied.

5.1.6 Secure the switchboard to the floor using the fixing details supplied in accordance with the foundation and switchgear assembly drawings.

5.1.7 Fit the trucks into the panels and check that they line up correctly with the contacts locating properly.

5.1.8 Couple the busbars together, where they have been split, using fishplates, nuts, bolts and washers supplied.

5.1.9 Couple the buswire sections together.

5.1.10 Remove the lifting beams.

5.1.11 If load measuring resistors are supplied, fit these on top of each feeder unit. Each panel will then require two electrical connections to be made in addition to the mechanical fixing.

5.1.12 Connect the cables to each unit in accordance with the appropriate diagram.

5.2 SWITCHBOARD GROUNDED THROUGH RESISTANCE

5.2.1 Lay a suitable concrete foundation, that is, one that is flat and level. It must also contain cable holes and fixing pockets in the correct positions as shown on the foundation plan.

5.2.2 Cover the concrete with a layer of plastic resin cement, Amazite or equal to a thickness of 3/8". This should be continuous and over all surfaces of the fixing pockets. The method of securing the switchboard may require epoxy blocks and rawlplugs with greased bolts to be positioned in the fixing pockets before applying the plastic resin cement. If another method of securing has been selected by customer, this will not apply.

5.2.3 Mark out the front line of the switchboard in the floor. The position of this will be determined by the positions of the fixing pockets.

5.2.4 Remove the trucks from the switchboard and the greased bolts from the floor fixing pockets (if fitted). Position the switchboard with its front edge on the line marked out.

5.2.5 Where necessary use shims under the base to make the switchboard plumb and level. If the units are insulated from each other ensure that the shims do not bridge this insulation.

5.2.6 Link the portions of the switchboard together using the components supplied. For units insulated from each other these include insulating studs, bushes and washers.

5.2.7 Secure the switchboard to the floor using the greased bolts removed in Paragraph 5.2.4 or using any other agreed fixing procedure.

5.2.8 If the switchboards are insulated from each other, special steel bolts are used to link the units during shipment and these must be changed for the insulated links provided when the switchboard is in its final position.

5.2.9 Fit the trucks into the panels and check that they line up correctly with the contacts locating properly.

5.2.10 Remove the lifting beams.

5.2.11 Use a Megger to check that the level of insulation between each unit and ground is satisfactory.

5.2.12 Couple the busbars together, where they have been split using the fishplates, nuts, bolts and washers provided.

5.2.13 Couple the buswire sections togetheer.

5.2.14 If load measuring resistors are supppplied fit these on top of each feeder unit. Each panel will then require two electrical connections to be made in addition to the mechanical fixing.

5.2.15 Connect the cables to each unit in accordance with the appropriate diagram.

6. SETTINGS AND ADJUSTMENTS

6.1 CLOSING SOLENOID

(See Illustration S778A)

6.1.1 To check that the closing solenoid is correctly set, measure the gap V between the end of the prop arm 14 and the notch in the prop link 10 (See Illustration S778F). With the solenoid energized, this gap should be 1/32" to 1/16" (1.0mm to 1.5mm).

6.1.2 To reduce the gap, release nuts 25 and transfer shims 24 from their storage position immediately below nuts 25 to a position between the solenoid top plate and the underside of the truck top plate. For each nut 25 transfer an equal number of shims. These shims are slotted to facilitate transfer. To increase the gap, reverse the above procedure so that more of the shims are in the storage position. Ensure that nuts 25 are tight before re-checking the gap.

6.2 ARCING CONTACTS

(See Illustrations S778B, C, D and E)

6.2.1 To check that the arcing contacts are correctly set, measure the gap between the silver contact tip 56 on the moving arcing contact 57 and the auxiliary arcing contact fingers 64. With the moving arcing contact 57 just touching the fixed arcing contact 78, this gap should be 2.5mm.

6.2.2 To measure the gap between silver contact tip 56 and auxiliary arcing contact fingers 64, insert a 2.5mm rod tool No. 408267 between contact tip 56 and the face of contact fingers 64. When the arcing contacts touch, the rods should be just free to move.

6.2.3 To adjust the gap, raise the arc chute 166 and insert a 3/8" (10mm) thick x 3/4" (15mm) wide strip between the moving arcing contact 57 and ONE of the fixed arcing contacts 78.

6.2.4 Partially close the breaker until the interference between the square arcing contact nuts 69 is lost.

6.2.5 Adjust the contact nut 69 on the contact where the strip has been inserted and by trial and error arrive at the correct setting, inserting the strip each time for adjustment. When that one contact is correct, insert the strip in the other contact and similarly adjust until both contacts are exactly level.

6.2.6 There should be a gap of 2.0mm to 3.0mm between the top of both fixed and moving contacts and the associated arc runner.

6.2.7 When the moving arcing contact 57 is reduced by burning to half its original thickness at the point where it makes contact with the fixed arcing contact 78 (S773E) both fixed and moving arcing contacts should be changed and the auxiliary arcing contact fingers 64 should be examined to ascertain if these should be changed at the same time (See Para. 6.3.7).

6.3 MAIN CONTACTS

To obtain access for checking and setting proceed as follows:

6.3.1 Remove the arc chute 166 (S778N).

6.3.2 Release the two insulated return connections 41 by removing bolts 40 and 49 (S778B).

Note:

These connections perform the important duty of passing the fault current from the arc runner 2 to the bottom fixed contact 27 when the breaker opens on fault. It is most important that these connections should be replaced and properly tightened after adjustments are completed.

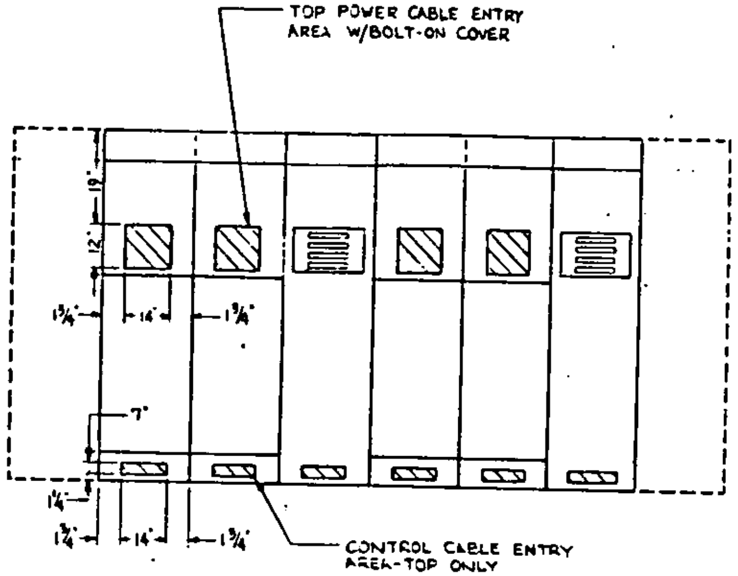
6.3.3 To check that the main contacts are correclty set measure the gap between the back edge of the brass contact guide 53 and the groove in the fixed contact finger 63. With the breaker closed this gap should be between 1.0mm and 1.5mm. This is shown as gap W on Illustration S778C, Figure 2.

Adjustment of the gap is made by adding or removing shims 8 (See Illustration S778P, Figure 2) to or from the space between block 7 and the vertical member of the mechanism. Adding shims will increase the contact pressure.

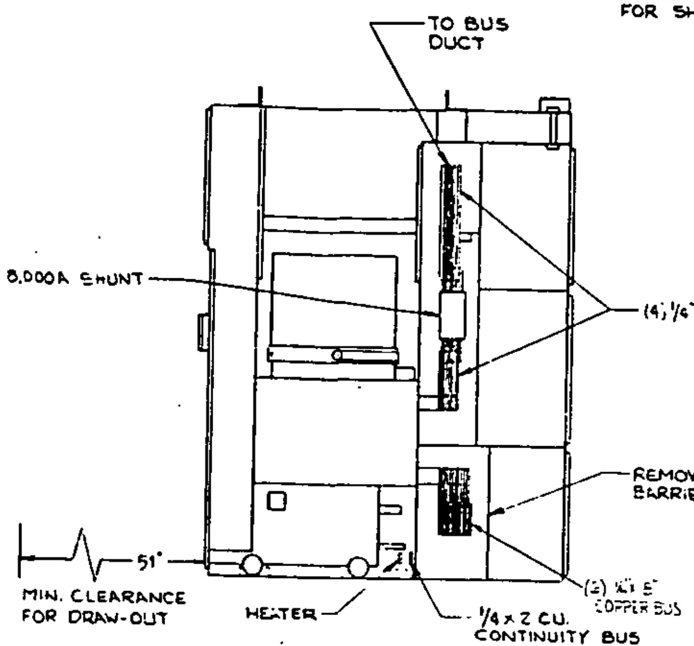
To adjust proceed as follows:

6.3.4 Ensure that the breaker is tripped. Release the two bolts 179.

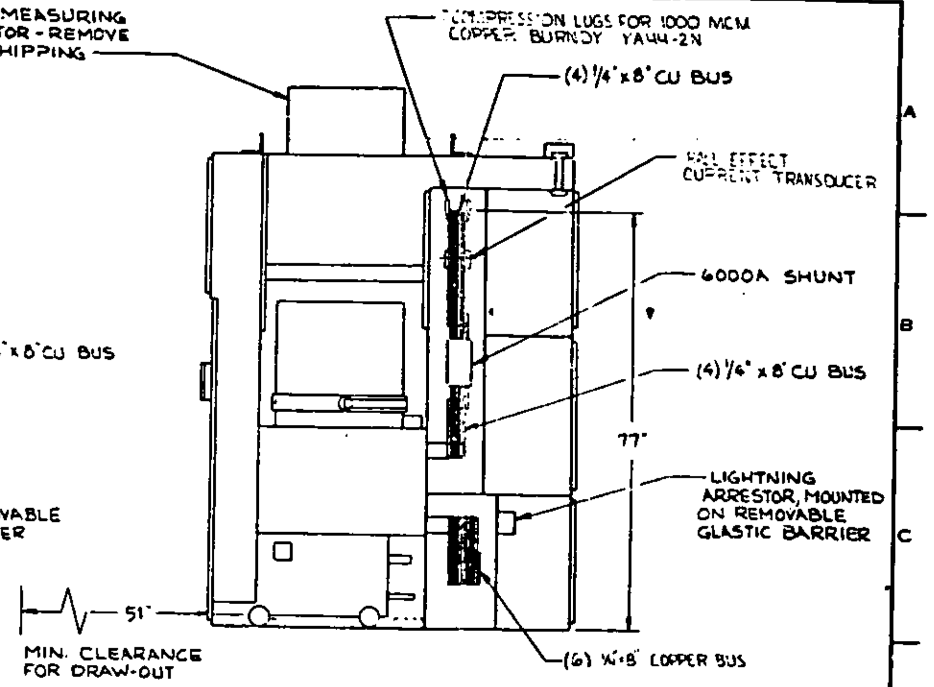
6.3.5 To increase the contact pressure take spare shims 8 from under the heads of bolts 179 and insert beneath the mechanism adjustment bracket 7 as shown in Illustration S778P.



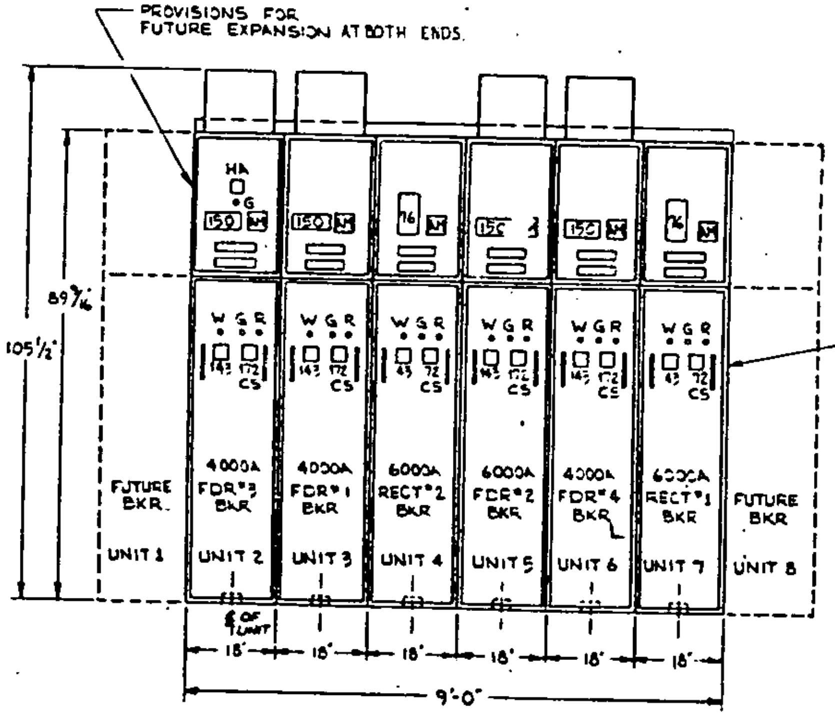
PLAN VIEW



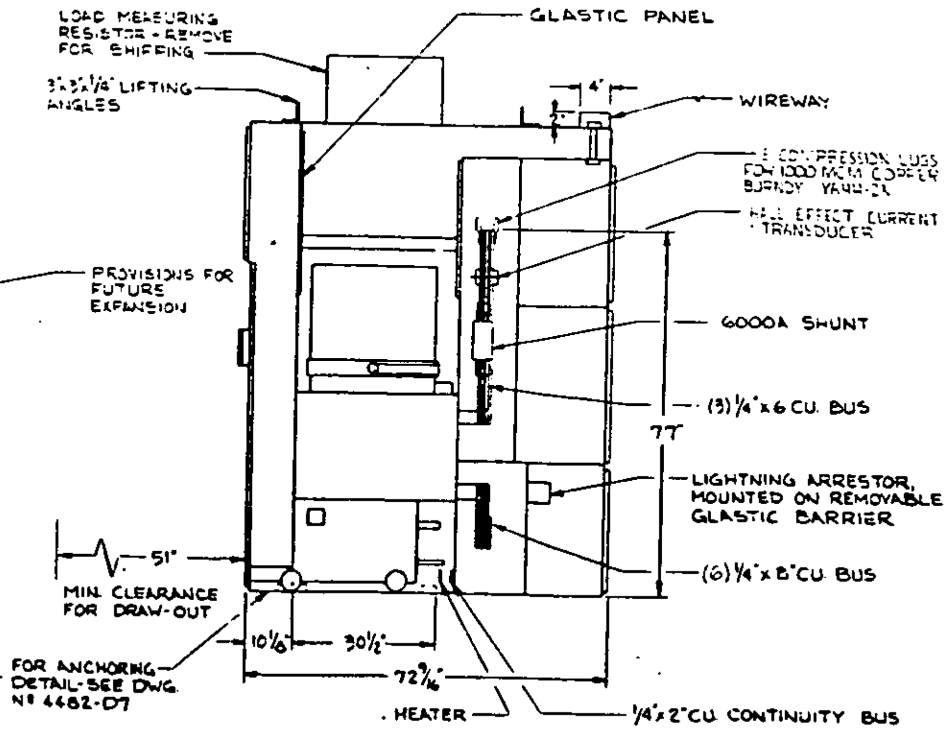
SECTION VIEW OF 6000A RECT. BKR.



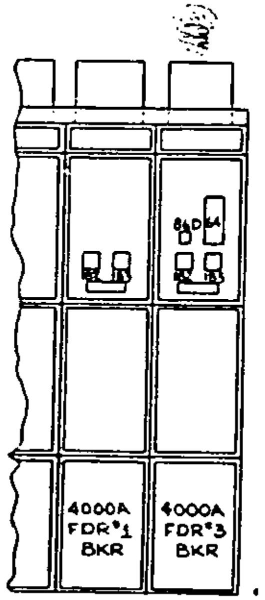
SECTION VIEW OF 6000A FDR. BKR.



FRONT VIEW



SECTION VIEW OF 4000A FEEDER BKR



REAR VIEW

FOR COMPLETE REAR VIEW SEE DWG. Nº 4482-C108

LEGEND

172CS	-BKR CONTROL SWITCH (FDR)
W	-WHITE LIGHT
G	-GREEN LIGHT
R	-RED LIGHT
AM	-AMMETER
64	-HIGH RESISTANCE GND. RELAY
86D	-LOCKOUT RELAY, SUBSTATION
143	-REMOTE/LOCAL SWITCH (FDR)
150	-RATE OF RISE RELAY
182	-CURRENT LOAD MEASURING RELAY
183	-VOLTAGE LOAD MEASURING RELAY
72CS	-BKR CONTROL SWITCH (RECT)
43	-REMOTE/LOCAL SWITCH (RECT)
HA	-HEATER AMMETER
76	-FORWARD CURRENT TRIP DEVICE

FINISH - LIGHT GRAY NO 61 ANSI Z 55.1 MINIMUM OF 2-MILS THK

WEIGHT -

SWITCHGEAR	- 7,200 lbs
BREAKERS (EA.)	- 650 lbs
TOTAL	-11,100 lbs

REV 1

FAS
5 2/88

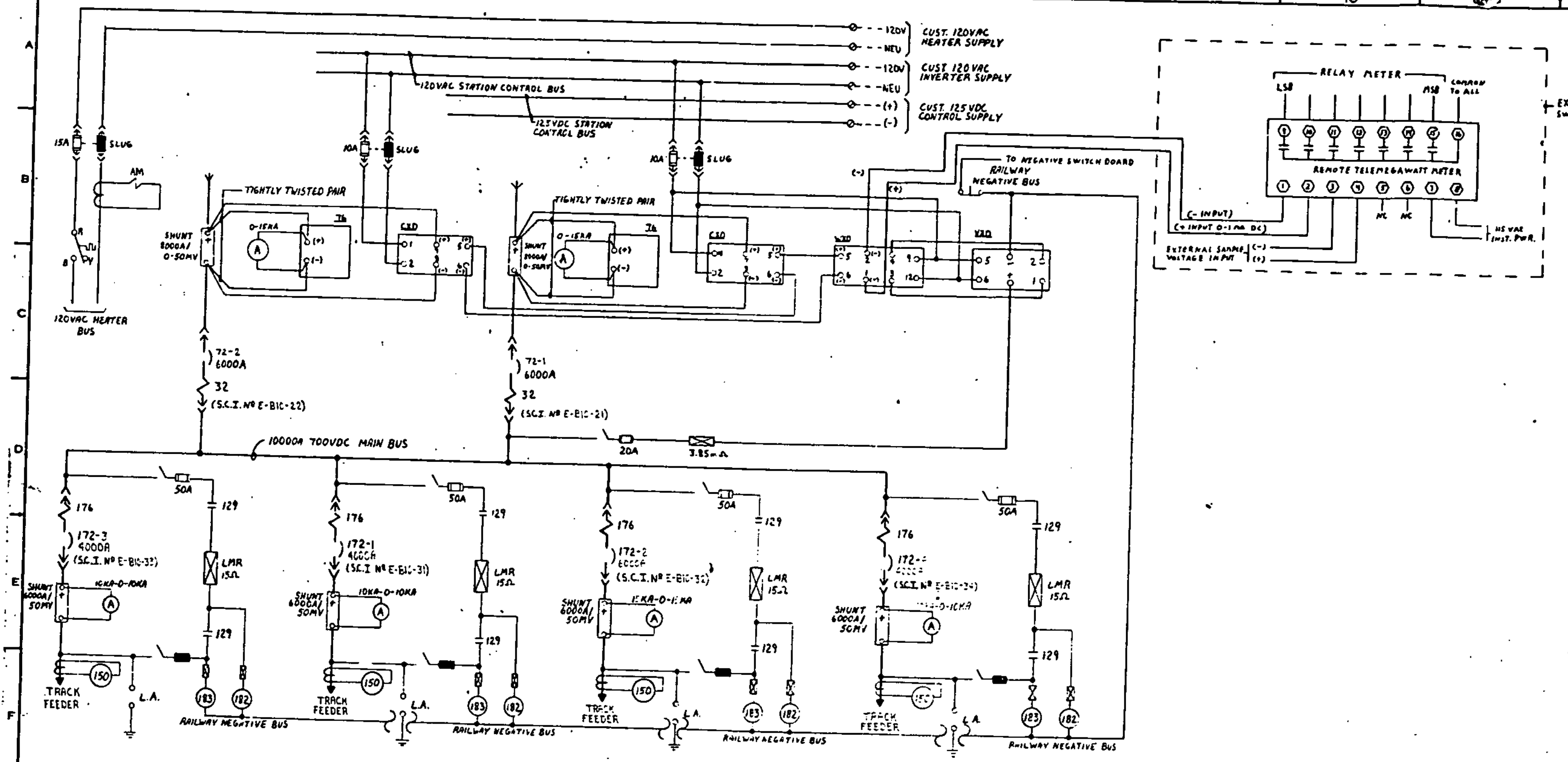
CONTROLLED POWER CORP

WMATA/SS-9
CONTRACT # 121049
KINGSTON CONTRACTORS

ELEVATION OF
SUBSTATION EQUIPMENT SS-9
TRACTION POWER SUBSTATION
WINDHAM LANE
-D.C. SWITCHGEAR

4482-D11

MAY 25 1990



NOTES:
FOR DEVICE LEGEND SEE 4982-A1
FOR DRAWING REFERENCE SHEET, SEE 4482-B2

MICRO FILMED 1-4-93

C

JFK
5-19-88

CONTROLLED POWER CORP

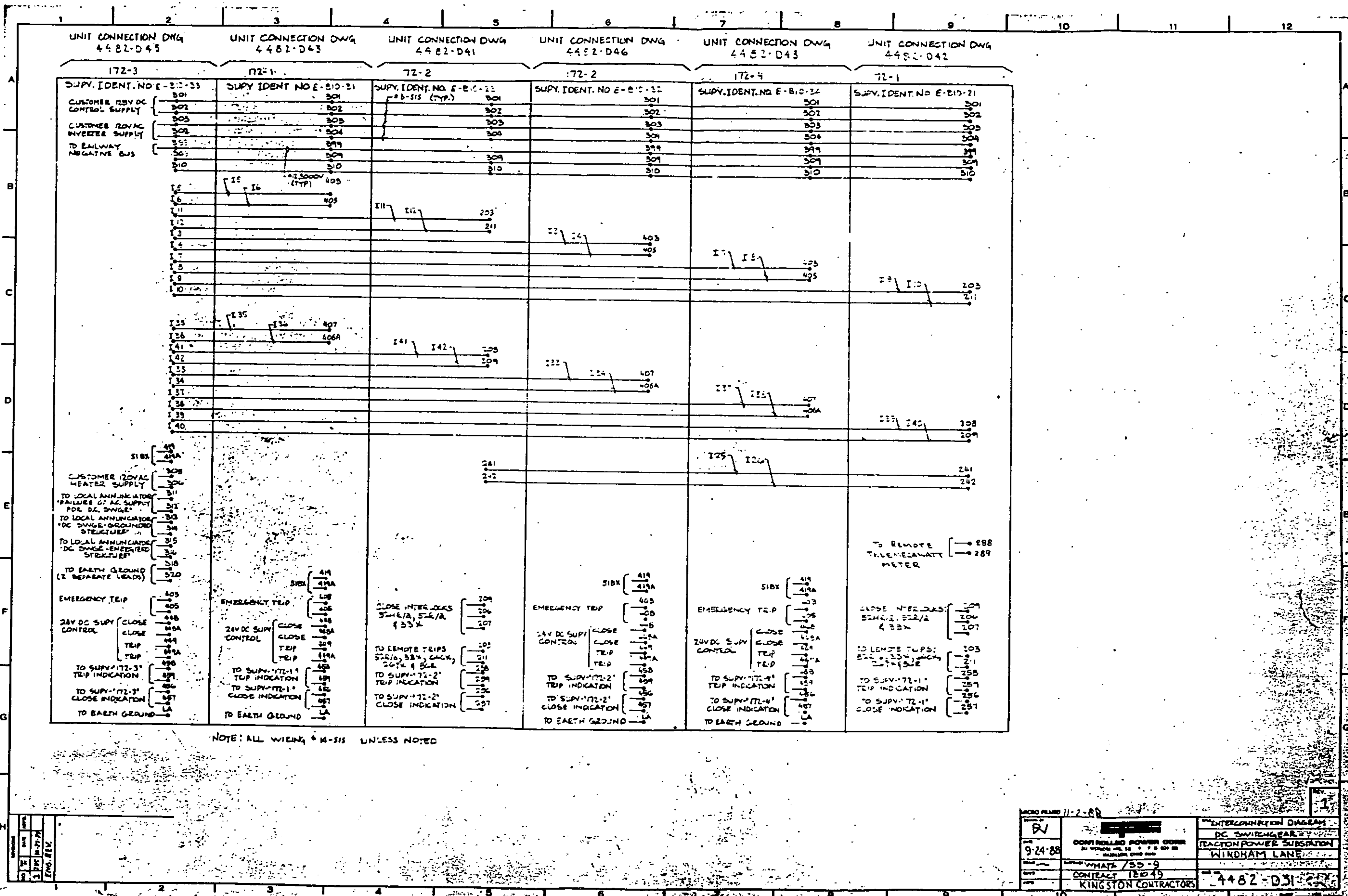
WMATA / SS-9
CONTRACT 1E1049
KINGSTON CONTRACTORS

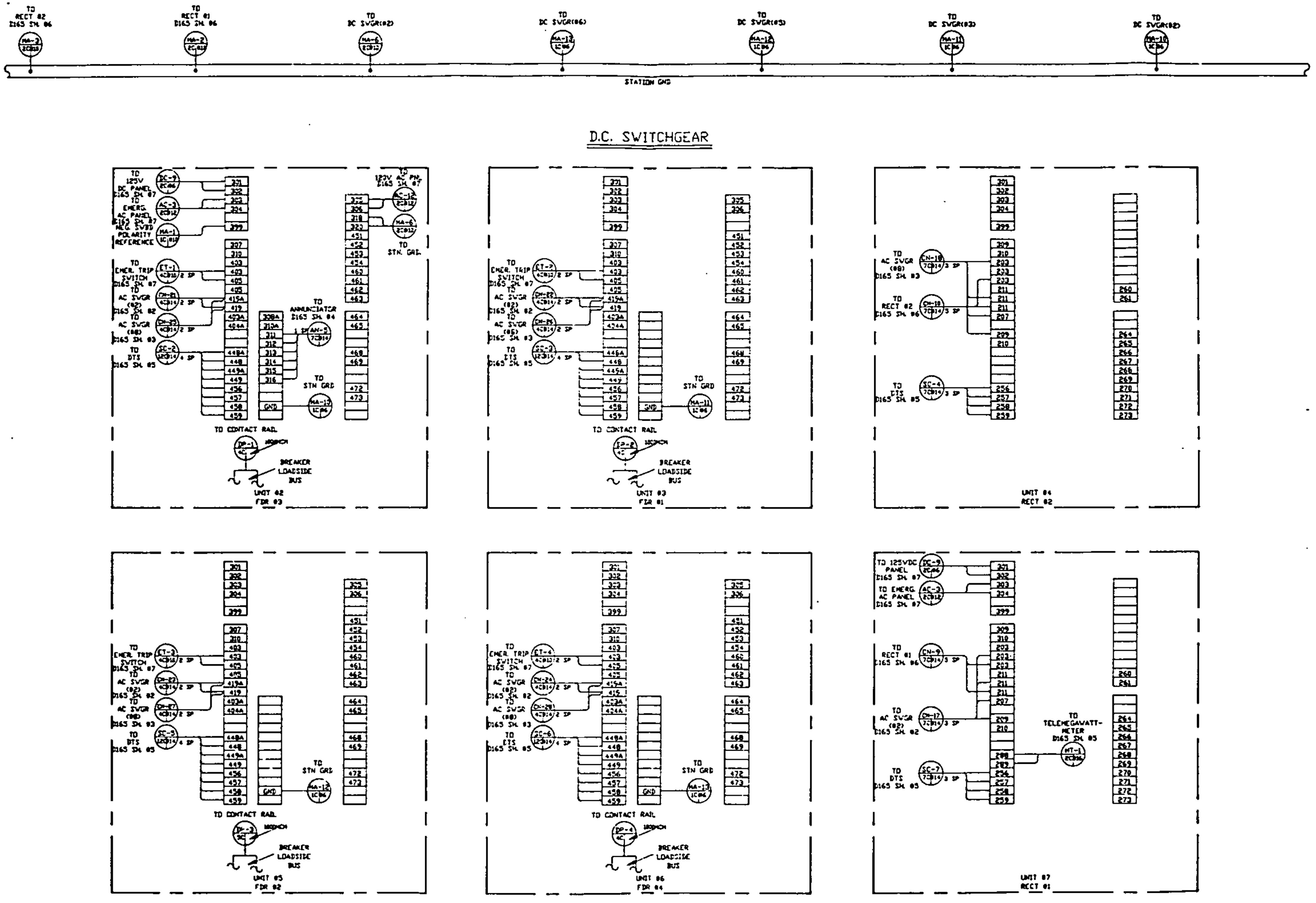
POWER DIAGRAM
DC SWITCHGEAR
TRACTION POWER SUBSTATION
WINDHAM LANE

4482-D21

D

MAY 2 5 1990


UNIT CONNECTION DWG 4482-D45
172-3
SUPV. IDENT. NO E-810-33
CUSTOMER 125V DC CONTROL SUPPLY
CUSTOMER 120V AC INVERTER SUPPLY
TO RAILWAY NEGATIVE BUS
301
302
303
304
399
309
310
UNIT CONNECTION DWG 4482-D43
172-1
SUPV IDENT NO E-810-31
#2 3000V (TYP)
UNIT CONNECTION DWG 4482-D41
72-2
SUPV. IDENT. NO. E-810-22
#6-515 (TYP.)
UNIT CONNECTION DWG 4452-D46
172-2
SUPV. IDENT. NO E-810-32
UNIT CONNECTION DWG 4482-D43
172-4
SUPV. IDENT. NO E-810-34
UNIT CONNECTION DWG 4482-D42
72-1
SUPV. IDENT. NO E-810-21
I5
I6
I11
I12
I3
I4
I7
I8
I9
I10
I35
I36
I41
I42
I33
I34
I37
I38
I39
I40
I25
I26
403
405
203
211
407
406A
205
209
241
242
51BX
419
419A
CUSTOMER 120V AC HEATER SUPPLY
305
306
TO LOCAL ANNUNCIATOR "FAILURE OF AC SUPPLY FOR DC SWGR"
311
312
TO LOCAL ANNUNCIATOR "DC SWGR-GROUNDED STRUCTURE"
313
314
TO LOCAL ANNUNCIATOR "DC SWGR-ENERGIZED STRUCTURE"
315
316
TO EARTH GROUND (2 SEPARATE LEADS)
318
320
EMERGENCY TRIP
24V DC SUPV CONTROL
CLOSE
CLOSE
TRIP
TRIP
448
448A
449
449A
TO SUPV "172-3" TRIP INDICATION
TO SUPV "172-3" CLOSE INDICATION
TO SUPV "172-1" TRIP INDICATION
TO SUPV "172-1" CLOSE INDICATION
456
457
458
459
LA
TO EARTH GROUND
CLOSE INTERLOCKS 52HE/A, 52E/A & 33X
204
206
207
TO REMOTE TRIPS 52E/b, 33X, 64CX, 26TX & 50E
TO SUPV "72-2" TRIP INDICATION
TO SUPV "72-2" CLOSE INDICATION
255
256
257
259
TO SUPV "172-2" TRIP INDICATION
TO SUPV "172-2" CLOSE INDICATION
TO SUPV "172-4" TRIP INDICATION
TO SUPV "172-4" CLOSE INDICATION
TO REMOTE TELEMEGAWATT METER
288
289
TO SUPV "72-1" TRIP INDICATION
TO SUPV "72-1" CLOSE INDICATION
NOTE: ALL WIRING #14-515 UNLESS NOTED
1
SRT
10-21-88
ENG. REV.
MICRO FILMED 11-2-88
RV
9-24-88
CONTROLLED POWER CORP
WMATA /55-9
CONTRACT 1E0049
KINGSTON CONTRACTORS
INTERCONNECTION DIAGRAM
DC SWITCHGEAR
TRACTION POWER SUBSTATION
WINDHAM LANE
4482-D31
1



REVISIONS

NO	BY	DATE
1	[illegible]	[illegible]

CUST. REV'S DP-3 AND MA-1C-2

MICROFILMED 9-9-99

NOTES:

1) DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-28, SS9-E-29, SS9-E-30, SS9-E-31, SS9-E-32, SS9-E-33, SS9-E-34, SS9-E-35, SS9-E-36, SS9-E-72.
2) ALL CUSTOMER CONNECTION TO D.C. SWITCHGEAR MADE ON FRONT METERING COMPARTMENT TERMINAL BLOCKS. (WITH EXCEPTION OF POWER CABLE CONNECTIONS)
3) SPARE TERMINALS IN DC SWITCHGEAR ARE SHOWN AS BLANKS

DRAWN BY D.H.
DATE 03/27/89
SCALE NTS
CHK'D.
APP'D.

CONTROLLED POWER CORP.

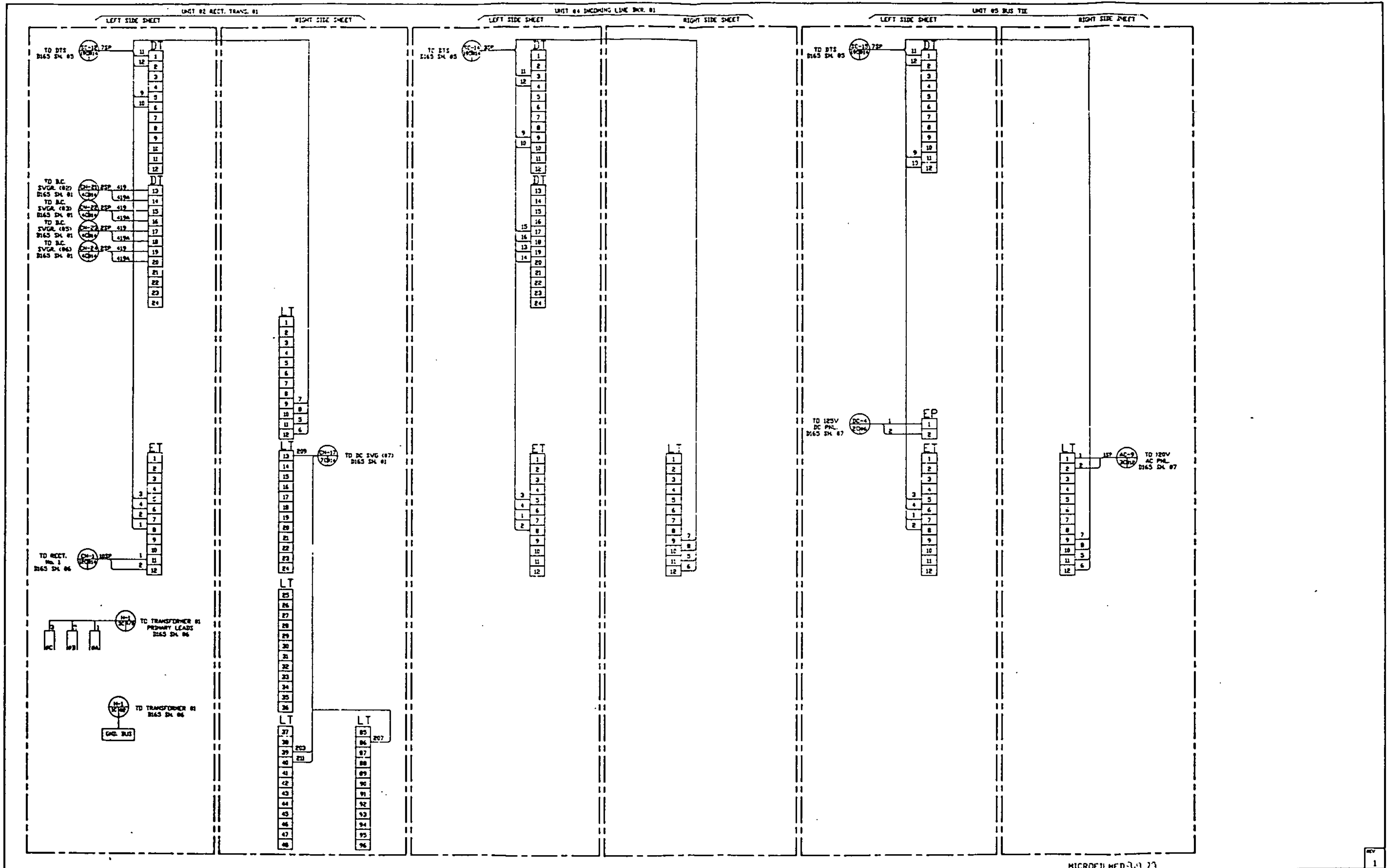
CUST. VMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE EQUIPMENT INTERCONNECTIONS FOR VINDHAM LANE SUBSTATION

DWG. NO. 4482-D165
SHT.# 1 OF 7

REV 1

MAY 2 5 1990



REVISIONS			
NO	BY	DATE	
1	JMS	8/03/89	CUST. REV. TO AC-9

NOTES:

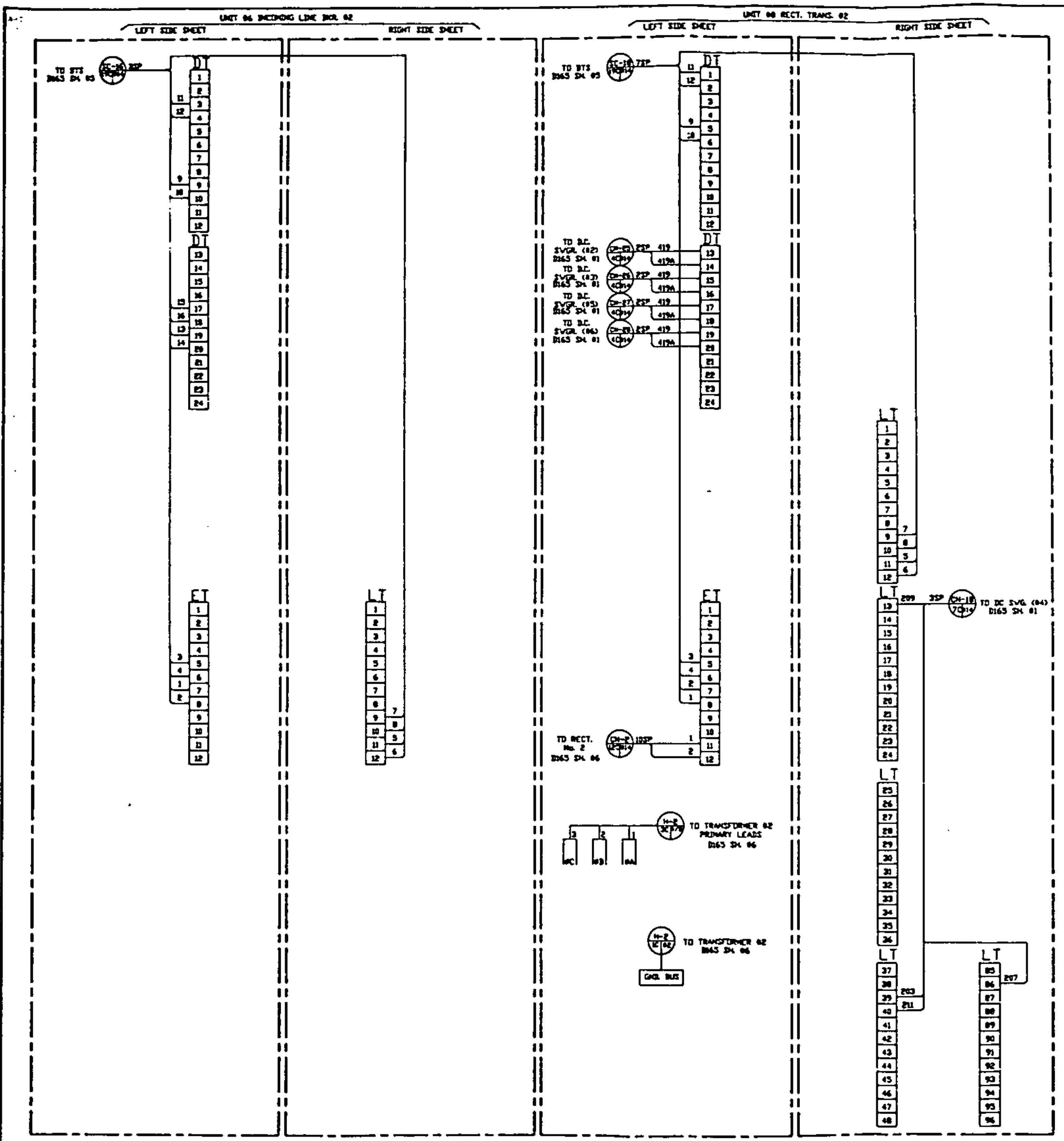
1.) DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-28, SS9-E-29, SS9-E-30, SS9-E-31, SS9-E-32, SS9-E-33, SS9-E-34, SS9-E-35, SS9-E-36, SS9-E-72.

MICROFILMED 7-9 23

DRAWN BY D.H.	CONTROLLED POWER CORP.	TITLE	EQUIPMENT INTERCONNECTIONS FOR WINDHAM LANE SUBSTATION
DATE 03/27/89			
SCALE NTS	CUST. VMATA/SS-9		
CHK'D.	CONTRACT #1Z1049	DWG. NO.	4482-D165 SHT.# 2 OF 7
APP'D.:	KINGSTON CONTRACTORS		

REV 1

MAY 25 1990



REVISIONS		
NO	BY	DATE

NOTES:

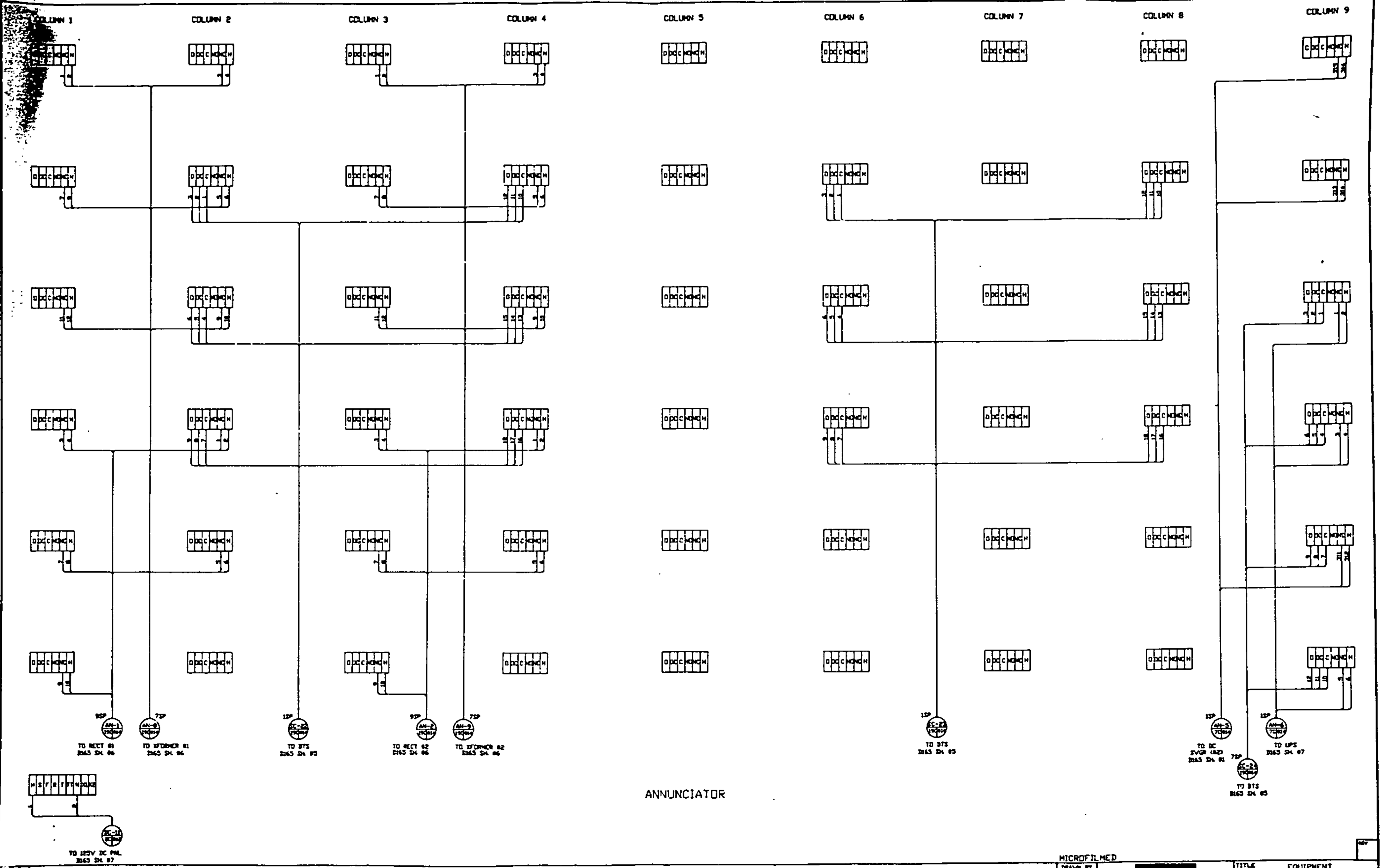
1.) DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-28, SS9-E-29, SS9-E-30, SS9-E-31, SS9-E-32, SS9-E-33, SS9-E-34, SS9-E-35, SS9-E-36, SS9-E-72.

MICROFILMED

DRAWN BY D.H.	[redacted] CONTROLLED POWER CORP.	TITLE EQUIPMENT INTERCONNECTIONS FOR WINDHAM LANE SUBSTATION
DATE 03/27/89		
SCALE NTS	CUST. WMATA/SS-9	
CHK'D.	CONTRACT #1Z1049	DWG. NO. 4482-D165 SHT.# 3 OF 7
APP'D.	KINGSTON CONTRACTORS	

REV

MAY 2 5 1990



NOTES:

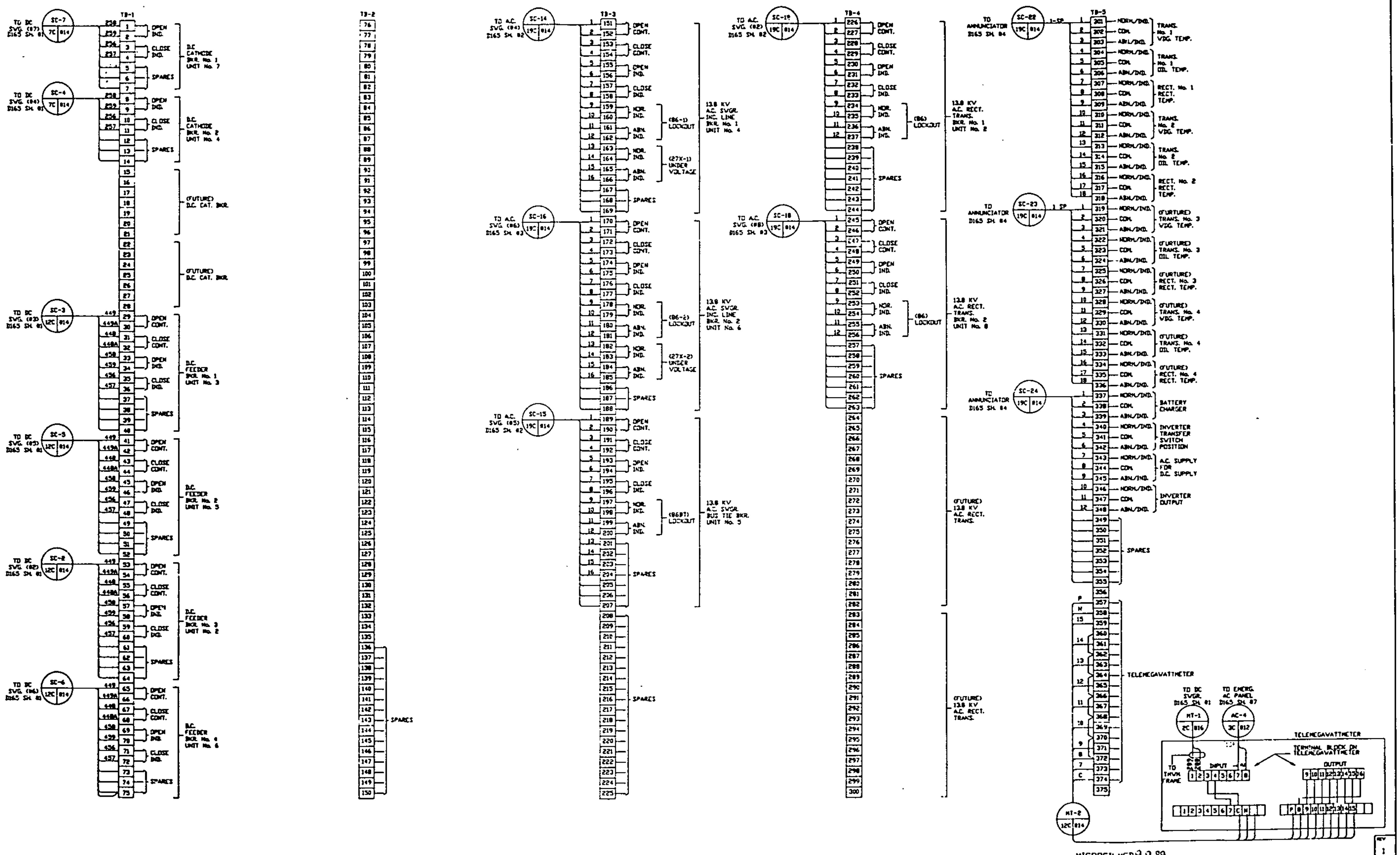
1.) DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-28, SS9-E-29, SS9-E-30, SS9-E-31, SS9-E-32, SS9-E-33, SS9-E-34, SS9-E-35, SS9-E-36, SS9-E-72.

MICROFILMED

DRAWN BY D.H.	[redacted] CONTROLLED POWER CORP.	TITLE	EQUIPMENT INTERCONNECTIONS FOR WINDHAM LANE SUBSTATION
DATE 03/27/89			
SCALE NTS	CUST. WMATA/SS-9		
CHK'D.	CONTRACT #1Z1049	DWG. NO.	4482-D165 SHT.# 4 OF 7
APP'L CM	KINGSTON CONTRACTORS		

REV

MAY 25 1990



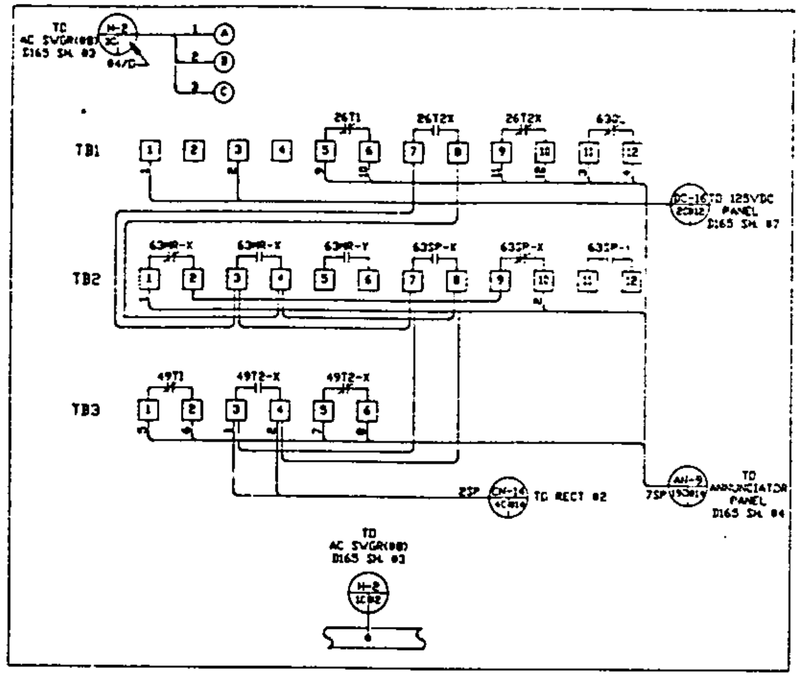
MICROFILMED 9-9-89

REVISIONS			
NO	BY	DATE	
1	MES	8/11/89	REVISED TERM BLOCK ARRANGEMENT AT TELEMEGAVATTMETER FOR TEST REVISION

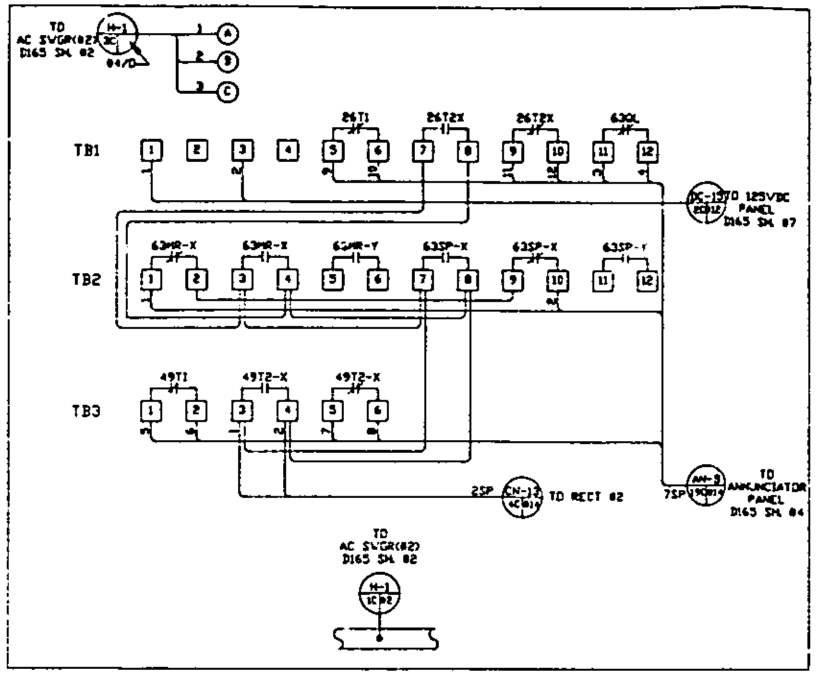
NOTES:
1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-28, SS9-E-29, SS9-E-30, SS9-E-31, SS9-E-32, SS9-E-33, SS9-E-34, SS9-E-35, SS9-E-36, SS9-E-72.

DRAWN BY J.H.S.	CONTROLLED POWER CORP.	TITLE	EQUIPMENT INTERCONNECTION FOR WINDHAM LANE SUBSTATION
DATE 03/29/89			
SCALE NTS	CUST. WMATA/SS-9		
CHK'D.	CONTRACT #171049	DWG. NO.	4482-D165 SHEET 5 OF 7
APP'D.	KINGSTON CONTRACTORS		

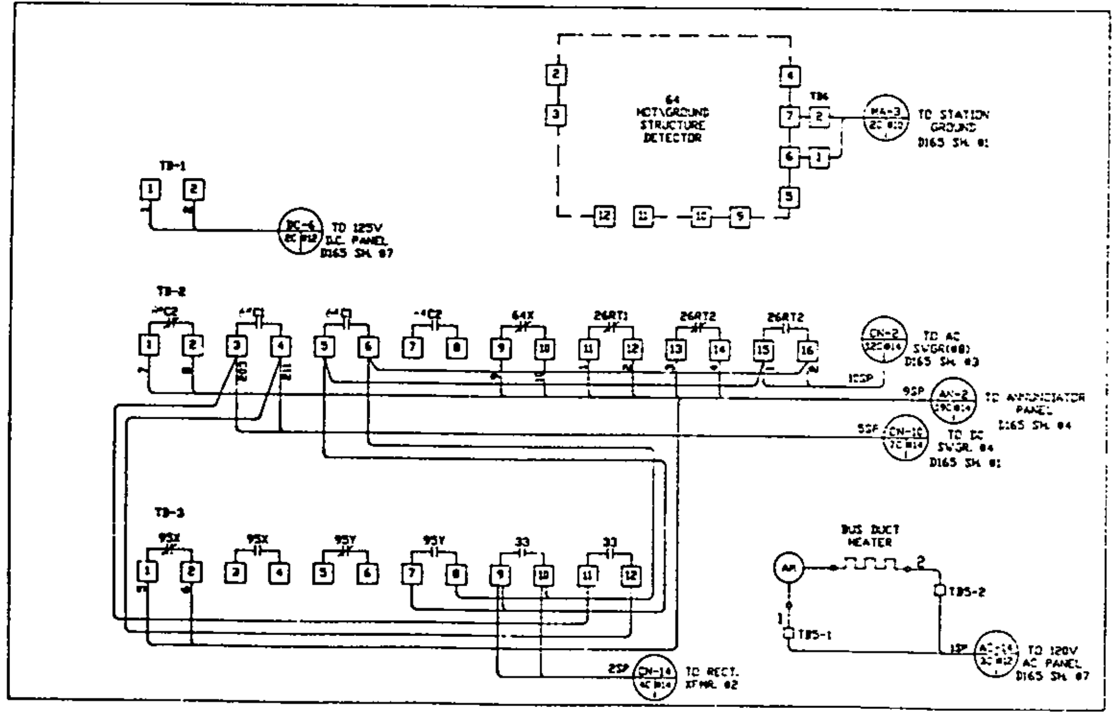
MAY 2 5 1990



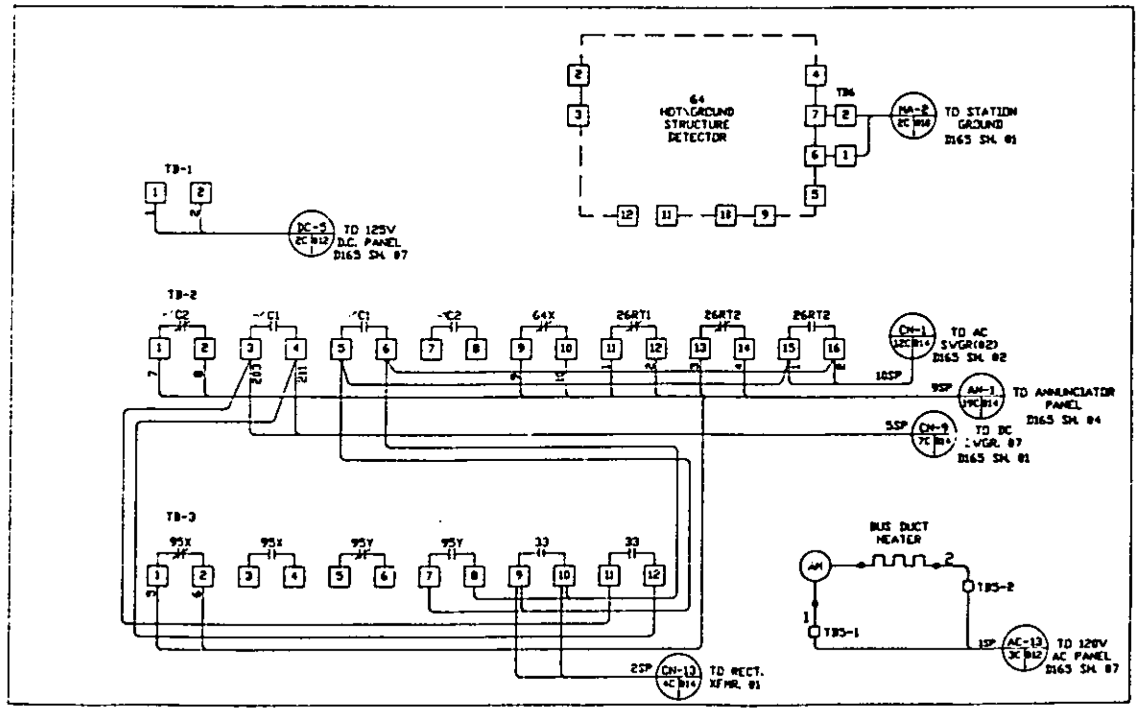
RECTIFIER TRANSFORMER #2



RECTIFIER TRANSFORMER #1



RECTIFIER #2



RECTIFIER #1

MAY 25 1990

MICROFILMED 9-7-79

REVISIONS			
NO	BY	DATE	
1	JAS	8/04/89	TEST REVISIONS

NOTES:

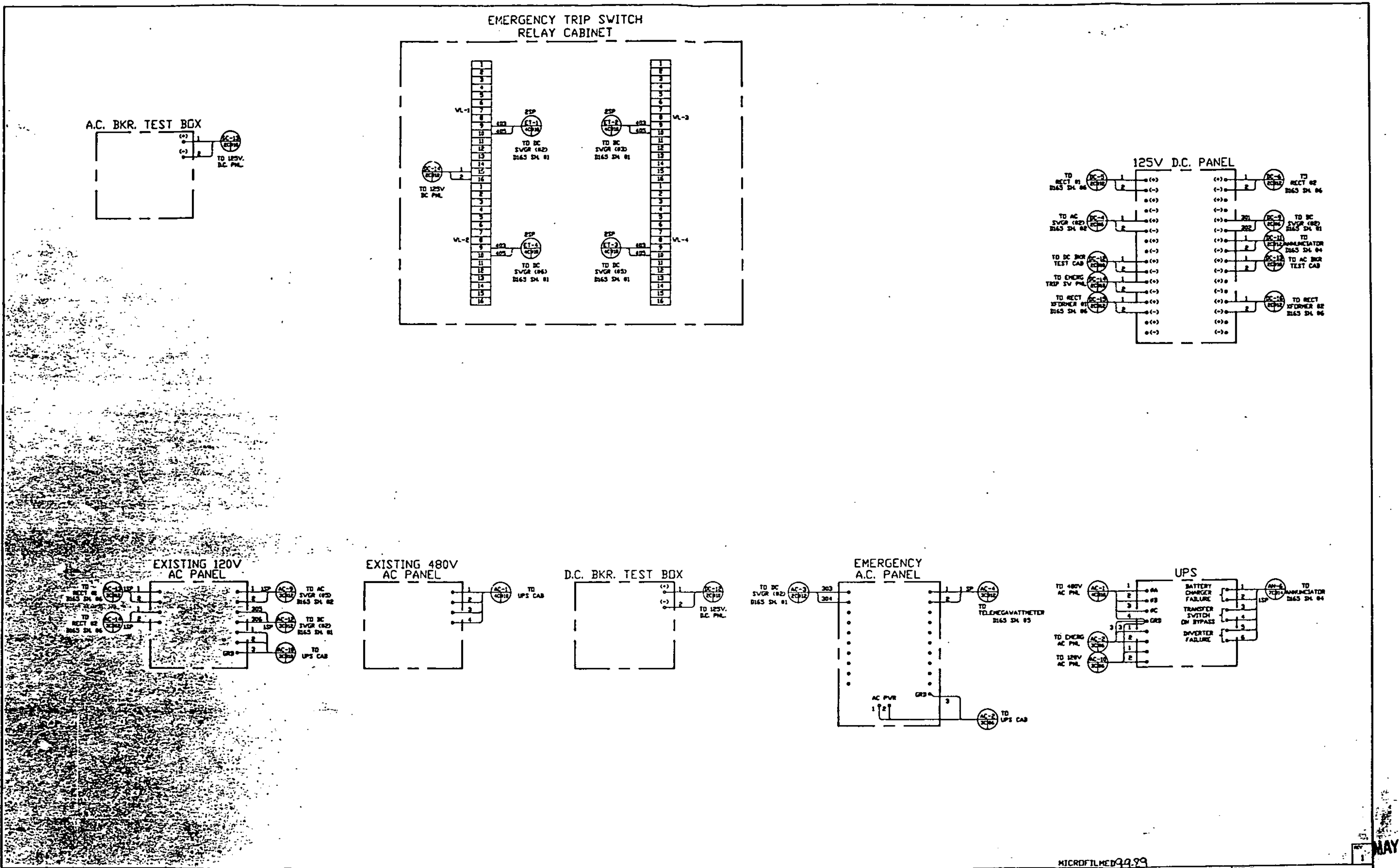
1.) DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-28, SS9-E-29, SS9-E-30, SS9-E-31, SS9-E-32, SS9-E-33, SS9-E-34, SS9-E-35, SS9-E-36, SS9-E-72.

DRAWN BY D.H.
DATE 03/27/89
SCALE NTS
CHK'D.
APP'D.

CONTROLLED POWER CORP.
CUST. WMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE EQUIPMENT
INTERCONNECTIONS FOR
WINDHAM LANE SUBSTATION

DWG. NO. 4482-D165
SHT.# 6 OF 7
REV 1



NOTES:

1.) DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-28, SS9-E-29, SS9-E-30, SS9-E-31, SS9-E-32, SS9-E-33, SS9-E-34, SS9-E-35, SS9-E-36, SS9-E-72.

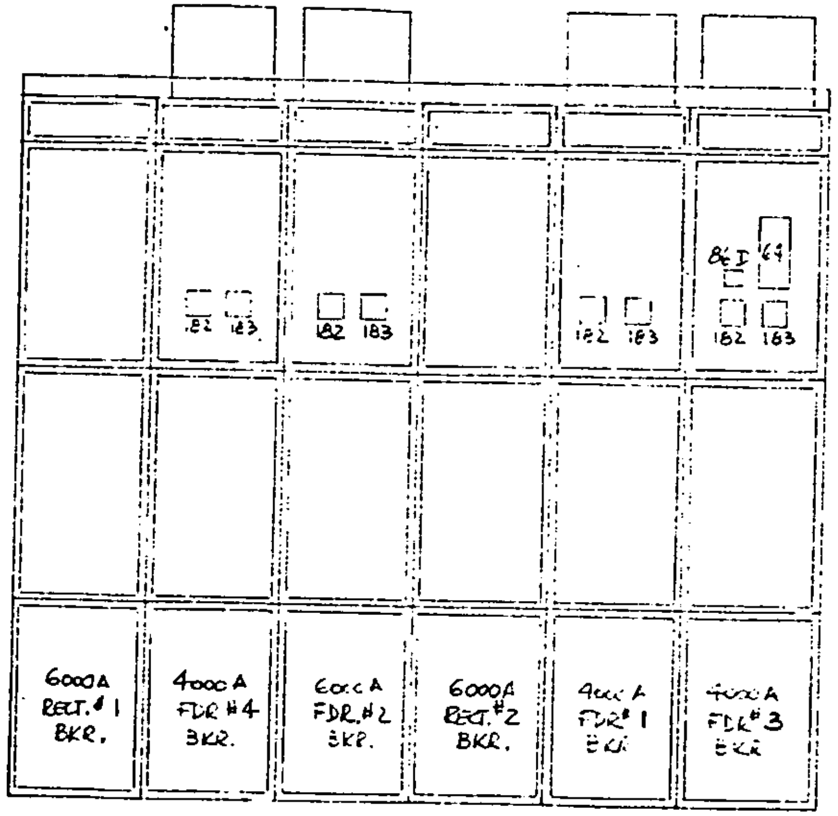
REVISIONS		
NO	BY	DATE
1	[illegible]	[illegible]

MICROFILMED 99.29

DRAWN BY D.H.	CONTROLLED POWER CORP.	TITLE	EQUIPMENT INTERCONNECTIONS FOR VINDHAM LANE SUBSTATION
DATE 03/27/89			
SCALE NTS	CUST. VMATA/SS-9		
CHK'D.	CONTRACT #121049	DWG. NO.	4482-D165 SHT.# 7 OF 7
APP'D EC!	KINGSTON CONTRACTORS		

REV. 1

MAY 25 1990



REAR VIEW

FOR ELEVATION & SECTION VIEW
SEE DWG № 4482-D 11

MICRO FILMED 9-30-88

DRAWN BY FBB
DATE 9/20/88
SCALE
CHK'D
APP'D

[redacted]

CONTROLLED POWER CORP.
211 WETMORE AVE. S.E. • P. O. BOX 633
MASSILLON, OHIO 44646

CUSTOMER WMATA/SS-9

TITLE REAR VIEW
TRACTION POWER SUBSTATION
WINDHAM LANE
D.C. SWITCHGEAR

DWG. NO. 4482-C108

REV.

Note:

The shims 8 are slotted for ease of insertion, but there is a locking plate with two holes which must always be placed immediately under the heads of the bolts 179.

Two sizes of shims are provided, the thinner shim being 0.7mm and this will be the shim normally used for adjustments.

6.3.6 Re-tighten the bolts 179 and close the breaker to check the effect of the adjustment.

6.3.7 Repeat the previous steps if necessary.

The two extended moving contacts 33 (S778B) at the center of the moving contact assembly carry a moving arcing contact 57, which is fitted with a silver cadmium oxide contact tip 56 (S778B). This is advanced so that it will contact the auxiliary arcing contact fingers 64 before the silver contact tips 55 on the moving contacts 35 touch either the advanced contact fingers 61 or the main contact fingers 63 (S778B and D).

The advance is such that when the moving arcing contact tip 56 makes contact with the longer auxiliary arcing contact fingers 64, there is a gap of between 6.0mm and 8.0mm between the silver tips 55 of the moving contact fingers 35 and the main contact 63. This is not adjustable and the auxiliary arcing contact fingers 64 should be changed when this gap is reduced to 4.0mm.

Extra spring pressure is required on the two extended moving contacts 64 because of their increased length and leverage. This is achieved by additional springs 183 (S778C) at the rear of the contacts located in a separate housing.

After all checks on the main contacts are complete, ensure that all the parts, which were removed to permit access, are replaced, and all screws tightened.

6.4 OPENING SPRINGS

(See Illustration S778P)

There is no adjustment for the opening springs 6. They are correctly tensioned when the nuts 178 with their springwashers have been screwed onto the spring retainer 180 far enough to cause the face of the spring retainer 180 to press firmly against the spring block 177.

Access to the nuts 178 is obtained by opening the front of the truck. The panel is secured by three screws at the right hand side of the panel.

Note:

The spring retainer 180 must always be assembled so that it is above the spindle upon which block 177 is mounted.

6.5 HALF SHAFT

(See Illustration S778F)

To adjust the half shaft proceed as follows:

6.5.1 Screw in the knife safety screw 85 until the circuit breaker will not close.

6.5.2 Screw out the knife safety screw 85 slowly until the breaker will just close when operated gently by hand.

6.5.3 Screw out the knife safety screw 85 a further 3 flats (half turn) and lock up.

Note:

Both locknuts on screw 85 must be tightened for each trial should not be unduly loose for adjustment to minimize free movement of the screw.

6.5.4 Adjust the half shaft limit screw 86 so that there is a 6.0mm gap between the end of the screw 86 and the bottom of the trip lever 87. This is shown as gap & on Illustration S778F, Figure 2.

6.5.5 Tighten both locknuts on limit screws 86.

6.6 TRIP KNIFE

(See Illustration S778F)

To adjust the trip knife proceed as follows:

6.6.1 Trip the circuit-breaker and allow to re-set.

6.6.2 Set the gap between the trip knife 81 and half shaft 82 to 1.0mm approximately. This is shown as gap X on Illustration S778F, Figure 1. This is achieved by adding or removing plain washers 80 from under the head of bolt 79. The two neoprene and two plain washers which are also in this position must not be removed.

6.6.3 Tighten the castle nut by hand onto the bolt 79 until finger tight i.e. just able to turn the assembly.

Then tighten a further half turn and lock up with a split pin.

6.7 HAND TRIP

(See Illustration S778F)

Check the gap between the striker nut 83 and the trip lever 87. This is shown as gap Z on Illustration S778F, Figure 2 and should be 3mm.

If necessary adjust by releasing locknut 84 and screwing striker nut 83 in the appropriate direction, afterwards secure with locknut 84.

6.8 OVERLOAD UNITS

(See Illustrations S778G and H)

The unit has been carefully set and calibrated in manufacture and should not need adjustment except in the case of complete dismantling~~.~~

The screw 108 has been set to give the correct armature gap and should not be disturbed. If by accident this adjustment is altered, it can be recovered as follows:

6.8.1 Trip the circuit breaker.

6.8.2 Turn the calibration screw 103 to minimum trip setting and look for a number generally between 5 and 7.5 stamped on top of the calibration screw bearing block.

6.8.3 Slacken the locknut on screw 108.

6.8.4 Close the armature 115 by inserting a screwdriver through the hole in the side plate of the breaker using the screwdriver as a lever.

6.8.5 While holding the armature 115 closed, tighten screw 108 by hand until it is finger tight (5 lb. in. if this is possible) and then screw out by the number of turns observed on the calibration screw bearing.

6.8.6 Lock up screw 108 with its locknut.

6.8.7 Re-set calibration screw 103 to required setting.

6.9 OVERLOAD TRIP ROD CLEARANCE

(See Illustrations S778H and J)

To adjust the clearance between the trip lever 116 and the striker nut 188, proceed as follows:

6.9.1 Slacken locknut 117 and screw the striker nut 118 until it just touches the trip lever 116.

6.9.2 Screw striker nut 118 back 1-2/3 turns (10 flats) and secure with locknut 117. On 2,000 amp and other low calibration applications with values less than 4,000 amps set the striker nut 118 back 3-1/3 turns (20 flats) and secure with locknut 117.

6.10 UNDERVOLTAGE RELEASE

(See Illustration S778K)

This is located behind the front panel door of the circuit-breaker, which can be opened by removing the three screws at the right rear of the panels, giving easy access.

The unit has been carefully set in manufacture and should not need adjusting except in the case of complete dismantling.

A variable D.C. voltage is required for re-setting this unit.

The unit is set as follows:

6.10.1 Trip the circuit breaker.

6.10.2 Adjust nut 123 so that the armature 125 picks up from its stop and closes against the core 128 when the voltage applied across the coil is raised slowly to 85% full voltage. Switch off supply.

Note:

Most undervoltage releases have series resistors connected and this must be taken into account when deciding the correct voltage to apply (See Diagrams for particular contract).

6.10.3 Set the screw 126 back so that its bottom end is just below the surface of the armature 125. Turn the screw 126 forward by very small amounts, applying full voltage to the coil for each trial and reducing the voltage, noting when the armature 125 releases. Repeat until the armature 125 is released at a value of approximately 20% of full voltage. Lock the screw 126 securely by its locknut 127.

6.10.4 (See Illustration S778J).

Set the striker nut 121 back so that the breaker can be closed without voltage on the undervoltage coil. Close the circuit breaker.

6.10.5 Operate the undervoltage armature by applying full volts and then switching off, each time advancing striker nut 121 until the breaker just trips when the voltage is switched off. Add 1/2 turn (3 flats) further for safety and lock up securely with locknut 122.

6.10.6 Check that the unit picks up at full voltage and that it is possible to close the circuit-breaker.

Check that with the breaker closed, the breaker trips when the voltage is switched off. Check too that the breaker cannot be closed without volts on the undervoltage coils.

Note:

This is an undervoltage release of the NO-VOLT type.

6.11 SHUNT TRIP

(See Illustration S778L)

To obtain access, open the front panel door of the circuit-breaker. Three screws at the back of the right hand side of the panel require to be removed to allow the door to open.

The shunt trip is set to allow the moving core 137 to rise and trip the breaker when 56% full volts is applied to the shunt trip coil 138.

Adjust the setting as follows:

6.11.1 Set the trip button 181 so that the trip poker 142 and moving core 137 have 1.5mm travel still available.

6.11.2 Remove nut 134 with its springwasher.

6.11.3 Add or remove plain washers under the head of screw 134 until the shunt trip will operate at 56% volts.

6.11.4 Secure with nut 134 and springwasher.

6.12 REVERSE CURRENT TRIP

(See Illustrations S778F and M)

The position of the trip armature 176 between the pole faces has been accurately set during manufacture and should not be disturbed. This position is decided by the stop screw 148 at the top of the unit. It is set so that the gap to the "trip" side is marginally greater than the gap to the "stop" side, thus ensuring stability.

The setting of stop screw 148 cannot be carried out easily with the unit in the breaker, but if the setting has been accidentally lost, it may be recovered as follows:

6.12.1 Trip the circuit-breaker.

6.12.2 Set the stop screw 148 well back and remove the spring 152.

6.12.3 Apply the full polarizing voltage to the coil.

6.12.4 Advance the stop screw 148 by small steps until the armature 176 "clicks" over center to the "trip" side.

6.12.5 Turn stop screw 148 back by 1/2 turn and lock up. Switch off the polarizing voltage, pull the armature 176 back against the stop screw 148 and switch the voltage on again. If the stop screw 148 has been correctly set, the armature 176 will stay agains stop screw 148, thus providing the requisite safety. If it "clicks" over, the stop screw 148 has been incorrectly set.

6.12.6 Calibration is achieved by adjustment of the return spring 152.

6.13 REVERSE TRIP ROD

(See Illustration S778F, Figure 2)

To adjust the clearance between the trip lever 87 and the striker nut 89 proceed as follows:

6.13.1 Slacken locknut 88 and screw the striker nut 89 until it just touches the trip lever 87.

6.13.2 Screw striker nut 89 back 1-1/3 turns (8 flats) and secure with locknut 88.

6.14 L.T. CONTACTS

(See Illustration S778P, Figure 1)

The L.T. Contacts must be even from end to end of the row, within the 1.0mm tolerance. The spring contact 171 must be firmly against the bottom of the slot in the insulated base 170.

The spring contacts 171 must be free from vertical displacement or distortion.

6.15 LOCKNUTS, SPLIT PINS AND CIRCLIPS

Before commissioning the breakers and after maintenance examine all locknuts to see that they are locked. Ensure that all split pins are in place and are open. Ensure that all circlips are in place in their grooves.

7. COMMISSIONING

7.1 INSPECTION

After unpacking and installing, before a breaker is put into service, check that:

7.1.1 All packing has been removed.

7.1.2 No parts have been damaged in transit.

7.1.3 The main and auxiliary plug-in contacts are clean and in good order.

7.1.4 The racking gear, shutters and interlocks are fully operational.

7.1.5 The trucks are lined up correctly and are interchangeable, where applicable.

7.1.6 No wiring has been damaged and that all buswires have been properly connected.

7.1.7 The breaker can be closed and tripped manually.

7.2 ELECTRICAL TESTS

All switchgear is fully tested before it leaves the factory, but it is desirable to subject small wiring of newly erected switchgear to a further electrical pressure test if this is at all possible.

It suitable supplies and apparatus are available, the small wiring should be subjected to a test of 1,500 volts A.C., 50 or 60 Hz for one minute.

All ground leakage equipment should be disconnected and voltmeters shorted out for this test and the main busbars and connections grounded. The main busbars and main breaker connections should be checked with a "Megger", with all breakers closed and the small wiring grounded. The main circuit can be hi-pot tested according to the particular specification for the contract or as a rough guide 2 x the working voltage + 1,000 volts.

7.3 ROUTINE TESTS

All relays and circuit-breakers can now be checked for proper electrical operation in line with diagrams and instructions for the particular contract. Start with the breakers in the "TEST" position and finally in the "SERVICE" position, observing that all instruments and alarms function correctly.

7.4 TRIP SETTINGS

The overload unit is adjustable over a pre-determined range usually with a 2/1 ratio. Adjustment is achieved by turning the calibration screw (Item 103 on Illustration S778G) at the rear of the breaker. The trip setting in kiloamps is shown on a graduated scale. The calibration is absolute and is independent of voltage variations and is bi-directional.

Before going into service, the overload unit should be set to the agreed trip setting for the particular application.

The reverse unit is directional and is not adjustable. This is pre-set usually at 10% of full load current and cannot be altered.

8. OPERATION

8.1 REMOVAL OF TRUCK AND BREAKER FROM HOUSING

8.1.1 Press the black trip knob 131 and turn clockwise until a "check" position is reached. This will trip the breaker, if it was closed and lockout the trip mechanisms.

8.1.2 Turn the knob 131 fully clockwise, against the resistance of a spring, which will open a shutter over the racking handle aperture at the bottom center of the front panel. While holding the knob against the spring pressure, insert the racking handle on to the racking shaft in the exposed aperture.

8.1.3 Turn the racking handle anticlockwise until the handle is free and the lead screw can be felt to be free from the nut.

8.1.4 Remove the racking handle, then the black knob will return to the "check" position. If turned fully anticlockwise the knob will move outwards and in this condition the breaker is in the "test" position and close and trip operations can be carried out.

8.1.5 Turn the knob 131 back to the "check" position and pull on the handles 197 to completely withdraw the truck and breaker from the housing.

8.2 REPLACEMENT OF TRUCK AND BREAKER IN HOUSING

8.2.1 Press the black trip knob 131 to trip the breaker if closed and then allow the knob to return to the out position.

8.2.2 Insert the circuit-breaker truck into the housing as far as it will go (a click will be heard as the bolt engages). This is the test position and in this position all operations can be checked.

8.2.3 Turn the knob 131 fully clockwise against the spring resistance and insert the racking handle as described in Paragraph 8.1.2.

8.2.4 Turn the racking handle clockwise until the breaker is racked fully home.

Note:

Do not insert the racking handle in the fully withdrawn position and ram the truck home, as this action will damage the lead screw and nut. The "test" position must be reached before inserting the racking handle.

8.3 CLOSING THE BREAKER MANUALLY

8.3.1 The breaker can be closed manually in either the "test" or the "service" position for maintenance or emergency operations. A safety shutter can be provided which prevents the breaker being closed in the ""service" position. To close manually, proceed as follows:

8.3.2 Turn the trip knob 131 anticlockwise and allow the knob to move out.

8.3.3 Insert the closing handle vertically in the closing handle aperture (on front panel midway between the trip knob and racking handle aperture). Rotate the closing handle clockwise until the breaker closes and latches.

8.4 TRIPPING THE BREAKER MANUALLY

8.4.1 Depress the trip knob 131.

8.5 LOCKING OUT THE BREAKER

8.5.1 Depress the trip knob 131 and turn clockwise.

8.6 CLOSING THE BREAKER ELECTRICALLY

8.6.1 Turn the control selector switch, if fitted, to either the "local" or "remote" position.

8.6.2 Turn the control switch, if fitted, at the appropriate station (the breaker front panel for "local" or the supervisory control for "remote") the the "CLOSE" position. This will either close the breaker direct or start up the load measuring auto-reclose sequence, which will then close the breaker if the circuit is acceptable to the load measuring relays.

8.7 TRIPPING THE BREAKER ELECTRICALLY

8.7.1 Turn the control selector switch, it fitted, to either the "local" or "remote" position.

8.7.2 Turn the control switch at the appropriate station (the breaker front panel for "local" or the supervisory control for "remote" to "TRIP" position).

9. SAFETY PRECAUTIONS

In the United Kingdom, the Health and Safety at Work Act 1974 imposes a general duty on the employer to do what is reasonably practical to safeguard employees and the public in general from the risks arising from his business.

Inspection and maintenance the equipment must therefore be carried out in accordance with the apprpriate Factories Act and the British Code of Practice for the Maintenance of Electrical Switchgear B.S. 5405. No instruction in this manual takes precedence over the above.

In other countries, the operator must make himself familiar with any National or Local Safety regulations.

It should be particularly noted that once the circuit-breaker truck has been withdrawn, it is complete isolated and safe to work upon. This does not apply to fixed housing which, although shielded, contains isolating contacts, busbars, buswires etc., that are still energized and must be isolated and grounded elsewhere before any work is done upon them.

This instruction book may recommend the use of various oils, greases, solvents, adhesive sealants etc. It is important that these products should be used only in the manner for which they are intended and that any instructions and cautions contained in the Manufacturer's literature or package markings are followed.

10. MAINTENANCE

The continued efficiency of a circuit-breaker and the length of its working life will depnd upon the maintenance it receives. With regular attention, its ability to operate satisfactorily under emergency conditions will be preserved for many years.

10.1 ROUTINE MAINTENANCE

A circuit breaker in continuous service requires a regular check over all its functional elements.

10.1.1 MONTHLY

Check the automatic and manual closing and tripping of the circuit breaker.

Examine the breaker for superficial damage. To do this remove the front cover and raise the arc chute 166. Check bolts and screws for tightness, particularly the countersunk screws 31 and 73.

Clean off any accumulation of dust.

10.1.2 ANNUALLY

Thoroughly overhaul the breaker contact system, replacing any badly corroded contacts.

Check all mechanism settings and adjust if necessary replacing any doubtful components.

Inspect the arc chute and monitor the extent of arc erosion. The service life of the arc chute is exhausted when erosion has reduced the wall thickness in local areas to approximately half its original thickness.

Note:

Under "Spares and Replacement Procedures" advice is given as to when some parts should be replaced.

10.2 CLEANING

Dust all insulation carefully. Substations are frequently close to the railway track and may receive metallic dust from vehicle brakes. It is important to exclude all dust as far as possible.

The mechanism of the breakers should be wiped carefully, particular attention being paid to the trip knife 81 and half shaft 82.

10.3 LUBRICATION

No working surfaces should be allowed to become dry and a good high film strength lubricant should be used. For example: Shell Alvania No. 2 + 3% MoS2 grease.

10.4 CONTACTS

The arcing contacts, which are made of copper require little attention apart from removing blobs, which may appear after heavy short circuits.

The main contacts are silver faced and should be kept clean, to avoid damaging the fine silver face, harsh abrasives should not be used.

10.5 AUXILIARY CONTACTS AND SECONDARY ISOLATING CONTACTS

These contacts are heavily silver plated and should not be cleaned with harsh abrasives which would damage the silver face. Any regular switch cleaning fluid can be used for cleaning these.

11. SPARES AND REPLACEMENT PROCEDURES

11.1 ORDERING

Attention to the following points will hasten dispatch and ensure that the correct part is supplied.

11.1.1 Identify parts in accordance with the spares drawing in this instruction book or by reference to the other illustrations.

11.1.2 Always quote the serial number of the circuit breaker, together with the details on the rating plate, which is on the front side member of the breaker truck.

11.1.3 In the case of coils quote the ES number if this can be ascertained from the old coil, the voltage, if this is known, but always the serial number of the breaker.

11.2 ARC CHUTES

(See Illustration S778N)

These are removed and replaced by raising vertically. Apart from cleaning as recommended in the maintenance section of this book, it is not possible to service the arc chute or to replace detail parts.

The arc chute should be replaced when arc erosion has reduced the side plate locally to half its original thickness.

A complete new arc chute should be ordered.

11.3 CONTACTS

Replace both fixed and moving arcing contacts, when one of the moving contacts has worn halfway. Normally the moving contact is the first to wear.

11.4 ARCING CONTACTS

(See Illustrations S778B and E)

11.4.1 MOVING CONTACTS

(See Illustration S778B)

The moving arcing contact 57 is secured to the two extended moving contacts 33 which are positioned centrally in the moving contact assembly. The same moving arcing contact 57 is used irrespective of the current size of the breaker or the number of main contacts.

To renew the moving arcing contact 57, remove the four countersunk screws 73 and the complete moving contact side arc runner 2. Remove nuts 34 with the associated stud and the two countersunk screws 31.

The arcing contact can now be removed from between the two center blades. It is not usually necessary to replace the fiberglass backing plate.

As aluminum and copper are dissimilar metals, when re-making the joints between the moving arcing contact 57 and extended moving contacts 33, both surfaces should be cleaned and a similar jointing compound such as Cual-Aid should be applied, before clamping together.

Assemble the backing plate and the new copper moving arcing contact 57, fit the stud and two nuts 34, but do not tighten. Replace the countersunk screws 31, tighten the nuts 34 and then check that the new contact lies flat along the face of the aluminum blades to give the correct auxiliary arcing contact setting as described under "Settings and Adjustments - Main Contacts".

11.4.2 ARC RUNNERS

(See Illustrations S778B or E)

If it should be necessary to replace an arc runner 1 or 2 and not the fixed arcing contact 78,, this can be accomplished without disturbing any settings.

Lift off the arc chute and remove the four countersunk screws 73, which secure each arc runner. A hexagon wrench with a short reach will be required for this. If an arcing contact change is being carried out, the arc runner can be changed at the same time.

There should be a gap of between 2.0mm and 3.0mm between the top of both the fixed and moving arcing contacts 78 and 57 and the associated arc runners 1 and 2.

11.4.3 FIXED ARCING CONTACTS

(See Illustration S778E)

To change the fixed arcing contacts, proceed as follows, first removing the complete fixed arcing contact assembly.

(1) Remove the screws 71, which secure the flexible connections 70 to the base plate.

(2) Remove the four front screws 72 at the sides of the fixed arcing contact assembly.

The complete fixed arcing contact assembly, with arc runner can now be removed from the circuit breaker.

(3) Remove the countersunk screws 73 from one support plate 74 so that it can be removed leaving the other support plate still in place.

(4) With a suitable clamp or vice, compress the springs 65 JUST SUFFICIENTLY for the two square arcing contact nuts 69 to pass one another (i.e. about 3/8") (10.0mm) DO NOT OVER COMPRESS. Unscrew nut 69 and remove the fixed arcing contact 78 complete with springs.

(5) Remove the other fixed arcing contacts.

The complete fixed arcing contact is a replaceable spare and comes with stud.

Replacement of the fixed arcing contact is the reverse of the above procedure. Make sure that spring retainer 77, trunnion 66, buffer 67, buffer plates 68 and arcing contacts nuts 69 are all threaded onto the stud in the correct order. Be careful not to overtighten the springs during assembly and note that there are two springs (an inner and an outer) per contact.

Final adjustment can be carried out only when the fixed arcing contact assembly has been fitted to the breaker and is described earlier under - "Settings and Adjustment - Arcing Contacts". If it should be necessary to change the fixed arc runner 1 at the same time as the arcing contacts this should be done after the arcing contacts have been removed, bolting up to one side first.

Note that the arcing contact guide pin 76 is loose and must be located properly in its special bearing, which is lubricated for life.

Make sure that the flexible connections 70 are connected up and that screws 71, 73 and 72 are properly tightened.

11.5 MAIN CONTACTS

11.5.1 MOVING CONTACTS

(See Illustrations S778A and B)

All circuit breakers have two extended moving contacts 33 in the center which carry the moving arcing contact 57. The total number of blades varies with the current size as follows:

4,000 amp - 4

6,000 amp - 6

8,000 amp - 8

10,000 amp - 10

12,000 amp - 12

To remove the complete moving contact assembly proceed as follows:

(1) Open circuit breaker, remove arc chute 166 S778N.

(2) Remove screws 38 (S778B) and the complete moving side arc runner assembly.

(3) Open front panel of the circuit breaker by removing the 3 screws on the right hand rear of the panel.

(4) Remove the nuts from the spring retainers at the front end of the opening springs 6 (S778A), which are thus released.

(5) Remove the screws 44 securing the flexible connection 28 to the moving contacts 35 (S778B), retain the bridging connection which links all the blades electrically.

(6) Remove pin 42 which will free the springs 6, the spring spacers and the horizontal front links 3 (S778A) and the drive links to the puffer bellows.

(7) Remove pin 45 (S778B), which will free the complete assembly.

Examine the flexible connection 28. This connection provides the return path from the arc runner 2 to the bottom fixed contact 27 and passes heavy current during fault interruption. It is important and if damaged should be replaced. Individual blades cannot be replaced, the standard spare part is a complete assembly which varies according to the current size of the breaker. It is supplied with the moving arcing contact 57 already fitted. If in an emergency, individual blades have to be fitted, they should be lined up carefully on the pins 42 and 45, before the nuts 36 and

43 are tightened. A check should be made that the silver faces of the contact system are all exactly in line, correct where necessary by careful filing.

Tighten the nuts 36 and 43 to 25 lb./ft. (33 Nm) and then ream the two main holes to give a clearance of 0.002" to 0.004" (0.05mm to 0.10mm) over the pin diameter. This should be attempted in cases of extreme urgency only.

To replace the contact assembly proceed as follows:

(1) Place the contact assembly in position and insert pin 45. The pins are initially treated with graphite and a little oil or a good quality grease with molybdenum disulphide should be applied before insertion. Shell Alvania 2 + 3% MoS2 is suitable.

(2) Insert pin 42 picking up the two horizontal links 3 (these fit equidistant from the center of the assembly between the standard moving contacts 35 and the extended moving contacts 33) and also the spring spacers.

(3) Hook the opening springs 6 over the pin 42, these fit equidistant from the center of the assembly separated by four moving contact blades. Secure the pin 42 with washers and split pins.

(4) Re-connect the flexible connections 28. It is necessary to clean the adjoining faces of the bridging connection and the blades and to apply a jointing compound as these are made of dissimilar metals. A suitable compound is Cual-Aid.

Ensure that all the screws are securely tightened.

<u>Note:</u>

The bridging connection, which electrically joins all the aluminum moving contact blades must be located between the flexible connection 28 and the blades.

(5) Hook the face ends of the opening spring 6 through the spring retainer, pass the stems of the retainer through the spring block attached to the mechanism adjustment bracket 7 and secure with the nuts and springwashers removed during dismantling. These nuts are tightened until the flange of the spring retainer is brought into contact with the spring block.

Note that the spring retainer 180 (S778P) must always be assembled so that it is above the spindle upon which block 177 is mounted.

(6) Replace moving side arc runner assembly and tighten screws 38.

(7) Check contact pressure and arcing contact lead as described under "Settings and Adjustment - Main Contacts and Arcing Contacts".

(8) Secure front panel of circuit breaker, replace the arc chute 166.

11.5.2 FIXED CONTACTS

(See Illustrations S778A, B, C, and D)

To remove the complete fixed contact assembly, refer to Illustration S778B and proceed as follows:

Bottom Contacts

(1) Remove insulation connection 41 (S778B).

(2) Close the circuit breaker.

(3) Remove the hex head screws 52 from the bottom fixed contact assembly, to free the contact guide 53.

(4) Open the circuit breaker by pressing hard on the manual closing handle as though trying to further close the breaker and while retaining this pressure, release the prop arm (14 on S778A) by pulling its spring holder forward and slowly releasing the pressure on the closing handle, thus permitting the breaker to open. DO NOT TRIP the circuit breaker by its manual "Press to Trip".

(5) Remove the screw 172 (S778B) from each side of the spring channel 59 (S778C). Remove the pillar 46 from one side; this requires the removal of screw 47, which is achieved by obtaining access from underneath through the hole in the truck platform.

The complete assembly can now be removed by sliding sideways.

Top Contacts

(1) Remove the fixed arcing contact assembly (See 11.4.3).

(2) Remove the insulated connection 41 (S778B).

(3) Remove the nylon screws 173, thus freeing the finger shield 50 and disconnect the puffer drive links from pin 42.

(4) Remove the two screws 172 (S778B) and the spring guide 184 taking care not to lose the spring 183 (S778C) or spring holders 185 (S778C) and lift the contact guide off its dowel pins.

(5) The top fixed contact assembly can now be withdrawn forwards. It will be necessary to depress the finger shield 50 (S778B) while doing this.

This is easier when the bottom contact also has to be removed, if the bottom contact is removed first.

Examine the silver contact tips 48 and 51 and clean carefully if necessary.

Replacement of the complete assemblies is a reversal of the removal. Replace the top assembly first and close the breaker to replace the contact guide 53 onto the dowel pins.

Ensure that the springs and plungers are inserted in the housing, with the plungers at the rear, adjacent to the arcing contact assembly (S778C) before offering this up for re-assembly.

Ensure that the puffer nozzles 199 are re-sited correctly in the finger shield assembly.

Contact pressure should be checked and re-set if necessary according to instuctions given under "Settings and Adjustment - Arcing Contacts and Main Contacts". Replace arc chute.

Individual Contacts

(See Illustrations S778C and D)

In the case of fixed contacts, it is possible to replace individual contacts and this may be necessary as the center two top fixed contacts act as auxiliary arcing contacts, and will be subjected to some burning.

The complete assembly is as shown on Illustration S778D. The center two contacts at the top are extended to form auxiliary arcing contacts. These two contacts have additional spring pressure, because of their increased length, provided by the additional springs at the rear.

All current sizes have two extended auxiliary arcing contacts 64 at the top center. The equivalent center bottom contacts are advanced over the remainder but not extended in length.

On all breakers except 4,000 amps, the next contact on each side of the two extended auxiliary arcing contacts are advanced contact fingers 61 which are advanced but not extended and are similar to the two center bottom contacts.

8,000 amp breakers have two auxiliary arcing contacts 64 in the center, one advanced contact finger 61 on each side and then two half size contact fingers 188 and 187 on each side.

The individual contact fingers 63 (S778C) can be removed from the channel 59 by starting one contact at a time from either end and compressing the spring 60 with a compression Tool No. S408766 if a vice is available, or squeezing the contact guide and spring holder at the points "T" with slip-joint pliers or "channel-locks" if a vice is not available (S778C, Figure 2). With a little juggling, the grooved pin 58 will fall out releasing the spring and spring holder.

Replacing the contacts is somewhat easier; start at the center and note that the extended auxiliary arcing contacts have reduced length "tee" pieces 62 (S778C) and the advanced contact fingers 61 adjacent to them and those acting as center bottom contacts have a wider slot in the top to provide the advance.

All these must be returned to the position from which they were removed, or replaced with equivalent parts. All springs 60 are the same.

11.6 MAIN ISOLATING CONTACTS

These are replaceable spares and are all alike for various current sizes. The complete assembly should be ordered; individual contacts are not replaceable.

11.7 OVERLOAD TRIP

(See Illustration S778G)

It is not possible to remove the complete overload unit from the breaker without completely dismantling the bottom fixed contact 27, because the magnetic yoke 110 encloses it. It should never be necessary to remove the complete assembly.

To remove the overload springs 106, proceed as follows:

11.7.1 Trip circuit breaker.

11.7.2 Note the trip setting and turn the calibration screw 103 anticlockwise as far as possible to reduce the tension on the springs.

11.7.3 Remove screws 113 from top and bottom of the calibration bearing plate.

11.7.4 Remove screws 105 top and bottom and slacken screws 174 top and bottom. Do not release screws 109.

11.7.5 Slacken nut 111 and separate the two guide plates sufficiently to allow the trunnion 112 to pass beyond its slot.

The calibration screw 103, locating block, trunnion 112, bearing washer, springs 106 and spring guides are now free and the springs may be changed.

Replacement is a reversal of the above; ensure that the pips at the end of the spring guide locate correctly in the armature pressure plate 107. Be sure to re-set the trip setting to its original position before putting the breaker back into service.

11.8 UNDERVOLTAGE RELEASE

(See Illustration S778K)

The undervoltage release is mounted behind the front panel and is easily removed if the front panel of the circuit breaker is opened by removing the three screws on the right hand rear of the panel.

Disconnect the coil leads and ensure that these are properly connected and tightened on replacement of the unit and that the series resistor is in order.

The undervoltage release unit is secured to the top of the truck at the front with screws underneath. Re-set as described earlier.

11.9 UNDERVOLTAGE RELEASE COIL

(See Illustration S778K)

To remove the undervoltage release coil proceed as follows:

11.9.1 Open breaker front panel as previously described.

11.9.2 Disconnect coil.

11.9.3 Remove pin 129 and disengage the striker nut 121 from the trip lever. Do not disturb screws 130.

11.9.4 Remove pin 124 and swing the armature 125, links and spring, forward out of the way.

11.9.5 Unscrew the core 128 using the 2 flats provided to free the coil.

Replacement is a reversal of the above. Ensure that the striker nut 121 engages in the correct hole in the trip lever (See Illustration S778J) before replacing pin 129.

The setting should not have been disturbed but should be checked in accordance with the instructions under "Settings and Adjustments - Undervoltage Release".

Note:

Undervoltage releases usually have a series resistor which may have been damaged if the coil has burnt out and this will also require replacing.

11.10 SHUNT TRIP

(See Illustrations S778L and Q)

The shunt trip is mounted behind the front panel on a sub-panel 196. For access first remove the three screws on the right hand rear of the panel.

Remove clevis pin 189 and pivot screw 190 (S778L) and swing the associated links out of its way. Remove bolt 194 (S778Q) from both sides of the front truck shrouds and release but do not remove bolts 195.

The sub-panel 196 can now be swung outwards and downwards through 90 degree complete with its components and wiring to give access to remove the shunt trip assembly.

Disconnect the coil leads and ensure that these are properly connected and tightened on replacement of the unit.

Re-set as described earlier.

11.11 SHUNT TRIP COIL

(See Illustration S778L)

To remove the shunt trip coil proceed as follows:

11.11.1 Open the circuit breaker and remove from the housing.

11.11.2 Open front panel and lower the sub-panel as described in 11.10.

11.11.3 Disconnect coil leads.

11.11.4 Release spring 192.

11.11.5 Remove the four screws 133 which secure the shunt trip unit to the sub-panel. This will free the complete shunt trip assembly from the circuit breaker.

11.11.6 The moving core 137 is now free and can be removed from the bottom of the shunt trip assembly; care should be taken to retain the anti-cling washer 191 for replacement.

11.11.7 Remove the two bottom screws 136. This will release the bottom plate together with spool 139, and shunt trip coil 138.

11.11.8 Remove the two screws which secure the spool 139 to the bottom plate. The shunt trip coil 138 with its spool 139 will then be free.

Replacement is a reverse of the above; ensure that the anti-cling washer is in place.

The setting should not have been disturbed, but should be checked in accordance with the instructions under "Settings and Adjustment - Shunt Trip".

11.12 AUXILIARY SWITCH, INTERLOCK, COUNTER ETC.

Access for removal or checking of the auxiliary switch, the operations counter, the ON/OFF indicator, the Castell interlock and various auxiliary indicating micro-switches (if fitted) or wiring alterations or checks can be obtained by opening the front panel and releasing the sub-panel as in 11.10.

11.13 REVERSE CURRENT TRIP

(See Illustration S778M)

The reverse current trip magnet assembly encloses all or part of the vertical bottom fixed contact 27. It is divided into parts, a coil, 160, armature 176 and magnet assembly and a horseshoe magnet yoke 154. To remove the unit from the breaker, the two parts have to be separated.

To remove the complete unit proceed as follows:

11.13.1 Remove the circuit breaker from the housing.

11.13.2 Remove the clevis pin 151 from the top end of the armature. This pin is retained with a special spring clip which must be kept for replacement.

11.13.3 Remove the two screws 158 to free the spring adjuster 157, return spring 152 and clevis. Do not disturb the spring adjuster 157 or its nut 156. The bracket, return spring 152 and adjuster 157 should be left assembled to preserve its setting.

11.13.4 Remove the clevis pin 155, again keeping the spring retainer for replacement. This frees the trip rod which should be removed completely and kept for replacement.

11.13.5 Remove the coil leads, noting and marking so that each lead is returned to the same terminal.

Note:

Reversing these leads will reverse the current direction in which the unit will operate. If left off, the unit will not operate at all.

11.13.6 Remove the socket headed screws 149 (two on each side) to free the coil 160 and armature assembly 176 from the horseshoe yoke 154.

11.13.7 Remove the screws 147 from each side of the breakers, noting that on larger sized breakers there are spacing tubes between the unit and the breaker side panel 30.

The unit can now be removed from the breaker by lowering it and passing it underneath the mechanism. The horseshoe yoke 154 will be left behind. Replacement is a reversal of the above procedure. Make sure that the coil is correctly connected and that the trip linkage is free. A check should be make on the trip linkage clearance as described previously under "Settings and Adjustments - Reverse Current Trip".

11.14 REVERSE CURRENT TRIP COIL

(See Illustration S778M)

To replace the reverse current trip coil, the unit must be split and removed from the breaker as described previously in Section 11.13 - Reverse Current Trip.

With the coil and armature assembly removed from the breaker, to remove the coil, proceed as follows:

11.14.1 Remove the eight coil fixing screws 161 four at the top and four at the bottom.

11.14.2 Release re-set spring 150 at one end and swing the link 159 out of the way. Release M8 nuts and remove lower fixing bar.

11.14.3 The coil and armature assembly will now slide sideways from the yoke allowing the former-wound coil to be removed from the bobbin, which carries the pivot for the armature 176.

Replacement is a reversal of the above.

Note 1:

The coil can be fitted either way up without changing the direction of operation, but the leads must be connected the right way around i.e. the lead connected to the top before replacement of the coil must be connected to the top afterwards, similarly, the lead to the bottom must also still be in the same position.

Note 2:

Reverse current releases usually have a series resistor which may have been damaged and need replacing if the reverse coil has burnt out.

Note 3:

If on returning the circuit breaker to service, the breaker trips immediately load is applied, the coil has been incorrectly connected.

11.15 CLOSING SOLENOID COIL

(See Illustration S778A)

To facilitate removal of the coil, the breaker truck must be raised about 50mm by jacking or running up onto ramps.

11.15.1 Remove the split pin 182 in the racking shaft and withdraw the complete shaft from the front.

11.15.2 Disconnect coil leads.

11.15.3 Operate the trip lever 116 (S778J) and while keeping this in the operated position attempt to close the breaker with the manual emergency closing handle. This will raise the moving core 21 (S778A) without closing the breaker. Tie or hold the handle in this position.

11.15.4 Remove screws 22 and the bottom solenoid plate which can remain within the confines of the truck.

11.15.5 The coil can now be removed from the rear of the truck. If difficulty is experienced remove the two rear pillars 23. Should it be necessary for any reason, the complete solenoid can be removed by removing the pin through the guide roller 17, the screws holding the guide plate and the mounting nuts 25. The weight of the solenoid must be supported from the bottom for this operation.

11.15.6 Replacement is a reversal of the above. Settings should not have been disturbed but should be checked in accordance with Paragraph 6.1.

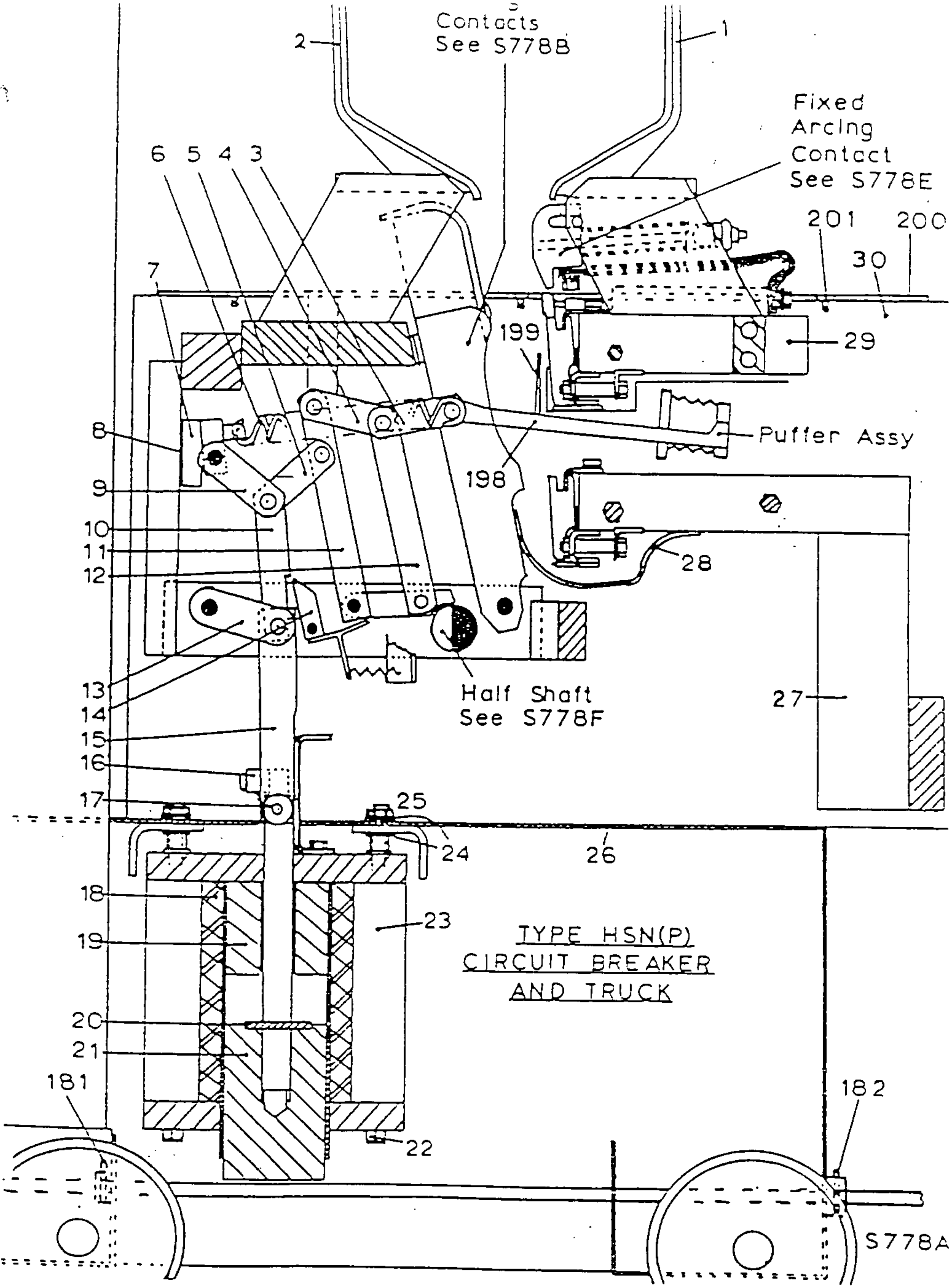
ILLUSTRATIONS

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778A

TYPE HSP CIRCUIT BREAKER AND TRUCK

1. Arc Runner (Fixed Contact Side)
2. Arc Runner (Moving Contact Side)
3. Horizontal Front Link
4. Horizontal Center Link
5. Horizontal Center Link
6. Opening Spring
7. Mechanism Adjustment Bracket
8. Mechanism Adjustment Shims
9. Horizontal Center Link
10. Prop Link
11. Center Link
12. Front Link
13. Guide Link
14. Prop Arm
15. Solenoid Link
16. Manual Close Roller
17. Guide Roller
18. Solenoid Coil
19. Solenoid Fixed Core
20. Buffer Washer
21. Solenoid Moving Core
22. Bolt
23. Spacing Pillar
24. Adjustment Shim
25. Nut
26. Truck

27.	Bottom Fixed Contact
28.	Flexible Connection
29.	Top Fixed Contact
30.	Breaker Side Panel
42.	Pin
181.	Split Pin
182.	Split Pin
198.	Puffer Drive Link
199.	Puffer Nozzle
200.	Insulation Plate
201.	Fixing Screw



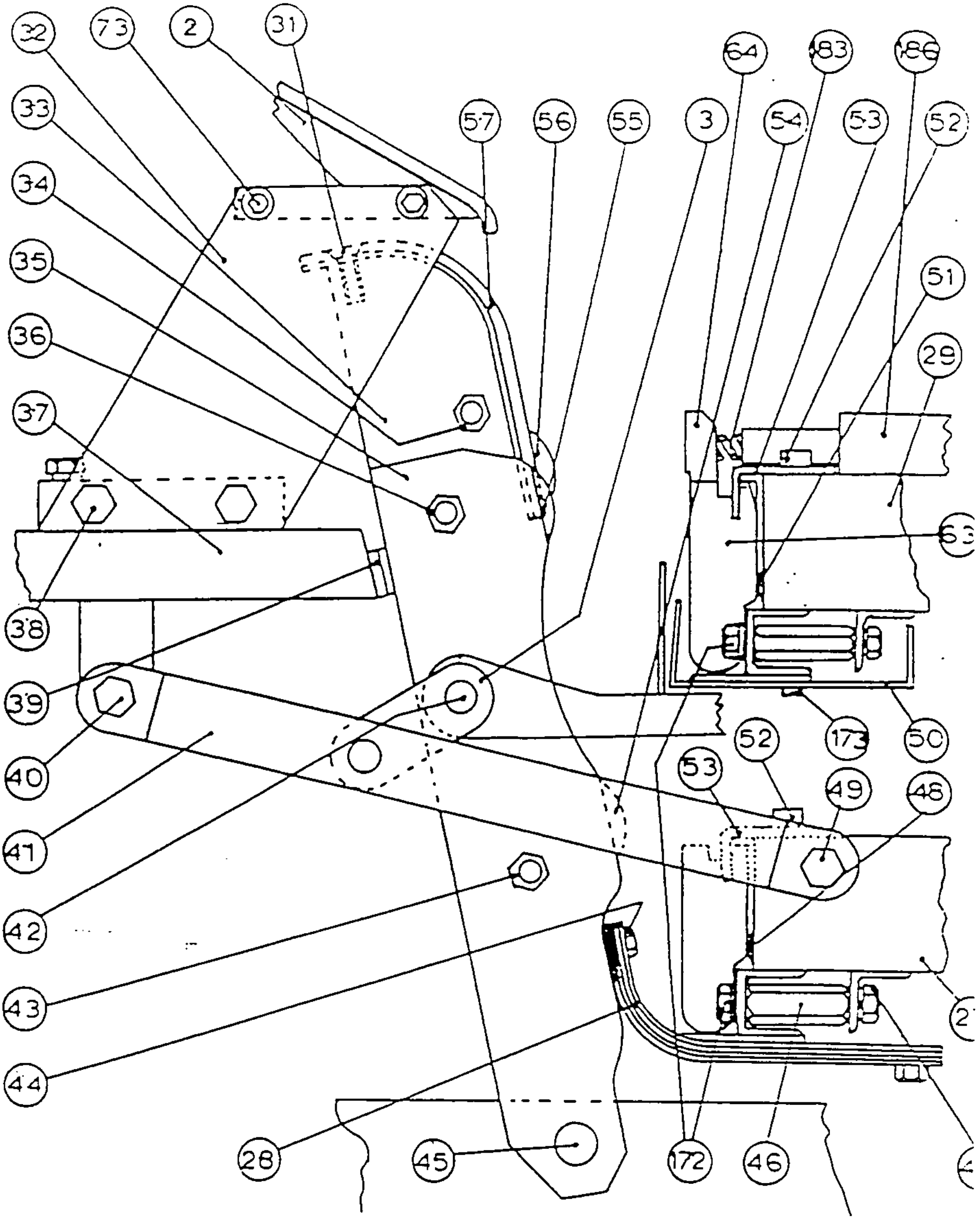
TYPE HSN(P)
CIRCUIT BREAKER
AND TRUCK

S778A

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778B

FIXED AND MOVING CONTACTS

2. Arc Runner (Moving Contact Side)
3. Horizontal Front Link
27. Bottom Fixed Contact
28. Flexible Connection
29. Top Fixed Contact
30. Breaker Side Panel
31. Countersunk Screw
32. Support Plate
33. Extended Moving Contact
34. Nut
35. Moving Contact
36. Nut
37. Stop Panel
38. Screw
39. Buffer Bar
40. Bolt
41. Insulated Return Connection
42. Pin
43. Nut
44. Screw
45. Pin
46. Pillar
47. Screw
48. Silver Contact Tip
49. Bolt
50. Finger Shield
51. Silver Contact Tip
52. Socket Screw
53. Contact Guide
54. Silver Contact Tip
55. Silver Contact Tip
56. Silver Cadmium Oxide Contact Tip
57. Moving Arcing Contact
63. Contact Finger
64. Auxiliary Arcing Contact Finger
73. Countersunk Screw
172. Screw
173. Nylon Screw
183. Spring
184. Spring Support Block



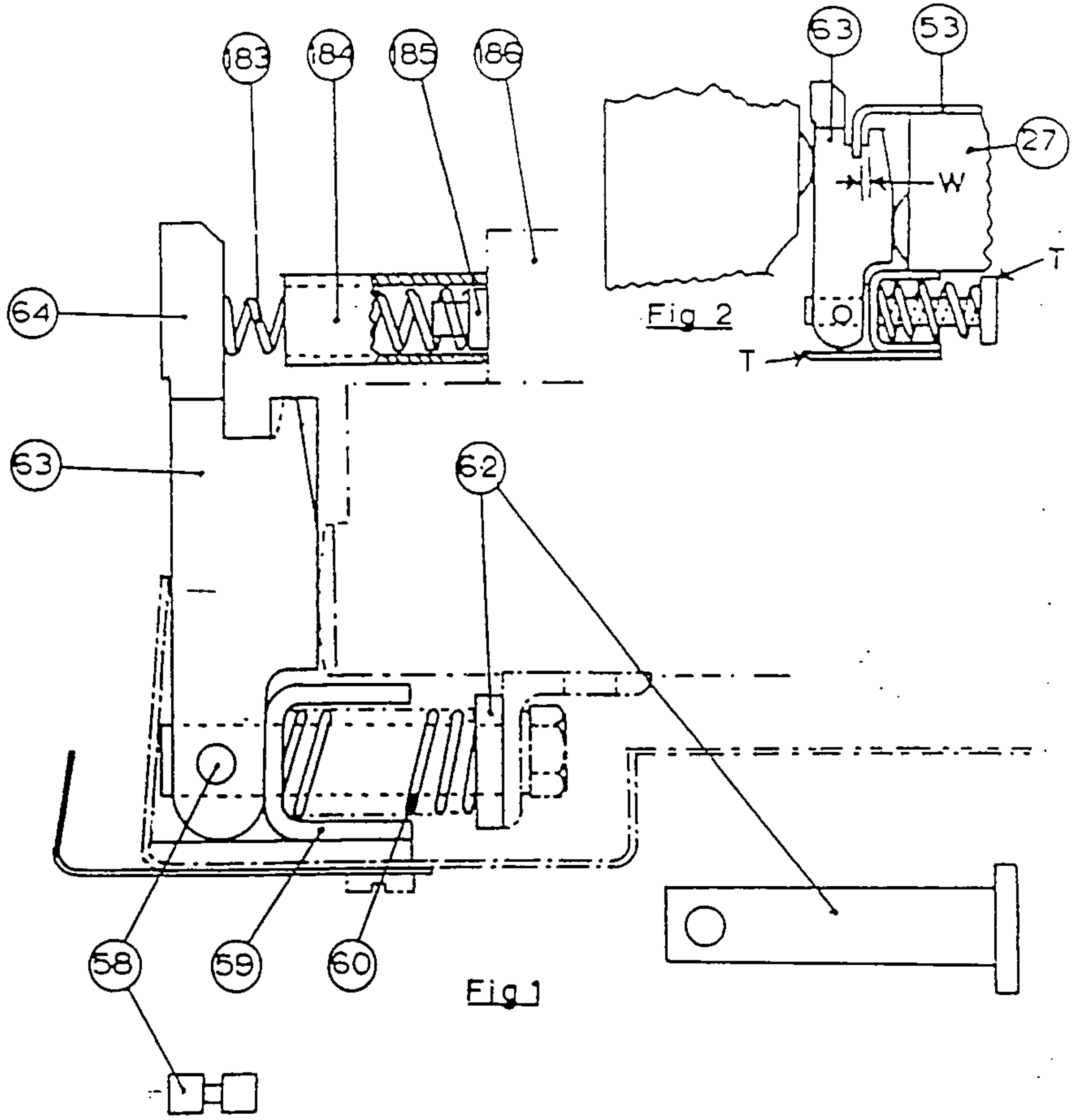
FIXED AND MOVING CONTACTS

S778B

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778C

FIGURES 1 AND 2 FIXED CONTACT ASSEMBLY

53. Contact Guide
58. Grooved Pin
59. Spring Channel
60. Spring
62. Spring Holder
63. Contact Finger
64. Auxiliary Arcing Contact Finger
183. Spring
184. Spring Guide
185. Spring Holder
186. Spring Support Block



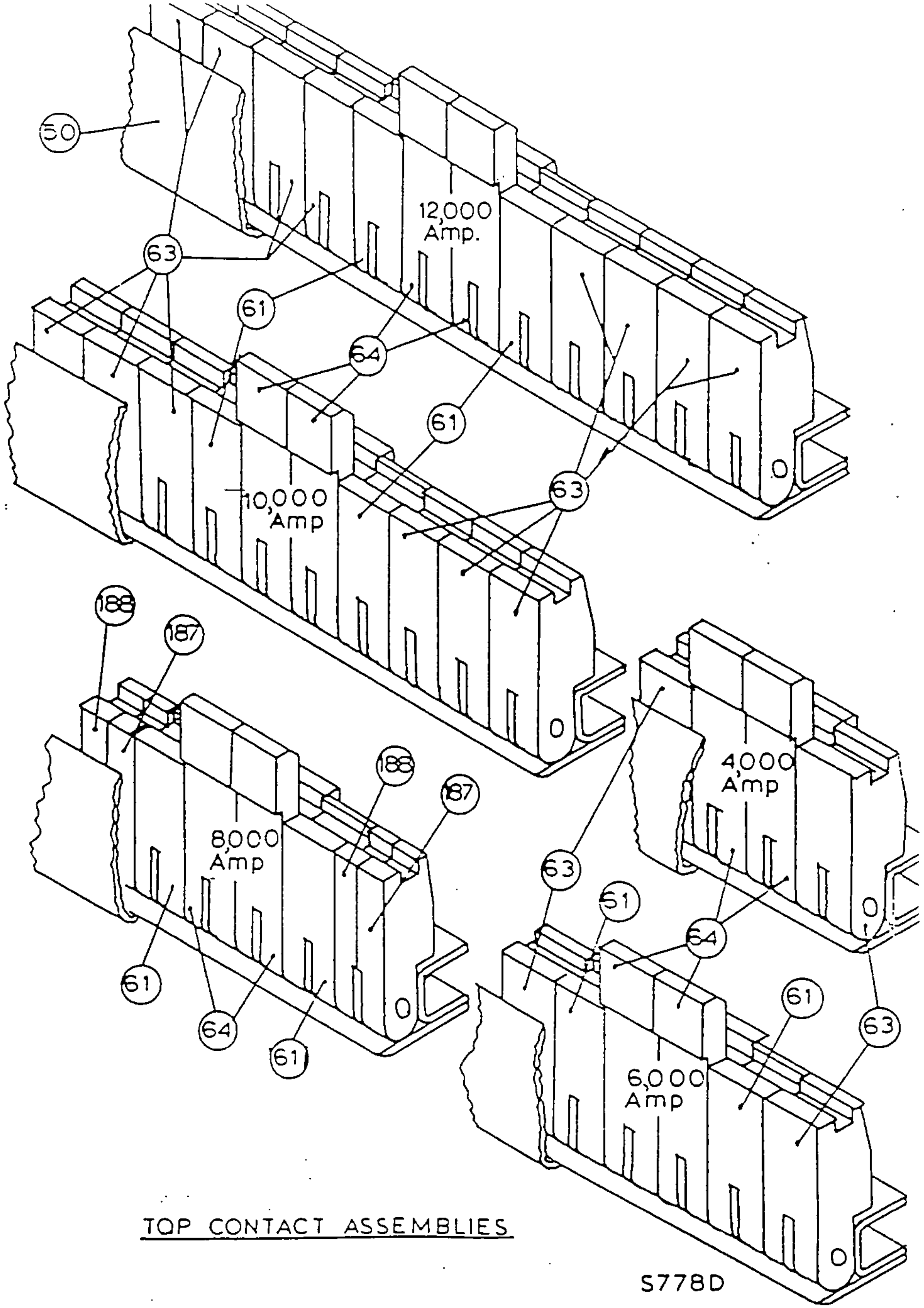
FIXED CONTACT ASSEMBLY

S778C

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S776D

TOP CONTACT ASSEMBLIES

50.	Finger Shield
61.	Advanced Contact Finger
63.	Contact Finger
64.	Auxiliary Arcing Contact Finger
187.	L.H. Half Contact Finger
188.	R.H. Half Contact Finger



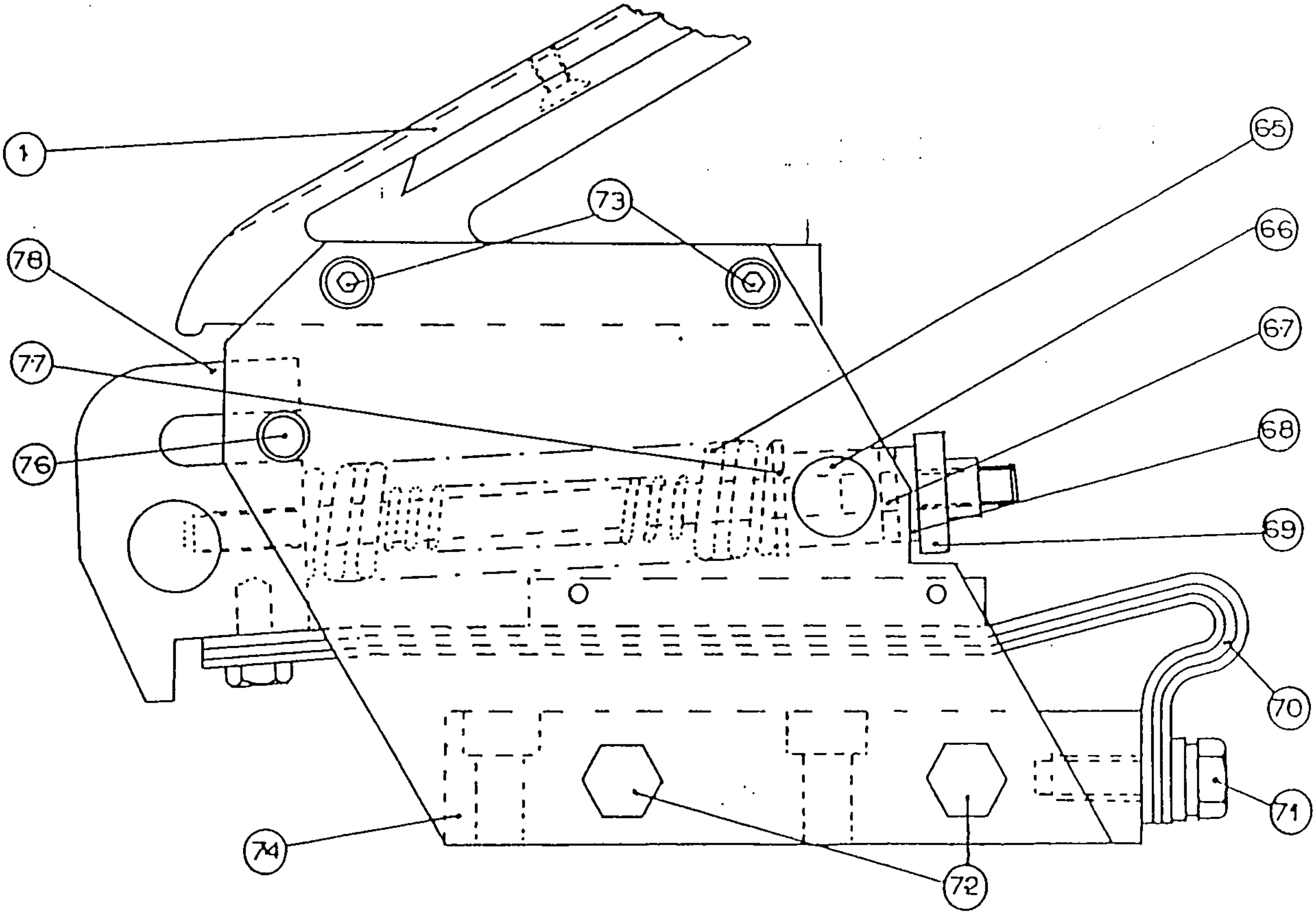
TOP CONTACT ASSEMBLIES

S778D

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778E

FIXED ARCING CONTACT

1. Arc Runner (Fixed Contact Side)
65. Springs
66. Trunnion
67. Buffer
68. Buffer Plate
69. Arcing Contact Nut
70. Flexible Connection
71. Screw
72. Screw
73. Countersunk Screw
74. Support Plate
76. Arcing Contact Guide Pin
77. Spring Retainer
78. Fixed Arcing Contact



FIXED ARCING CONTACT

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778F

FIGURE 1 - HALF SHAFT AND LOWER MECHANISM

FIGURE 2 - HALF SHAFT AND TRIPPING LINKAGES

10.	Prop Link
11.	Centre Link
12.	Front Link
13.	Guide Link
14.	Prop Arm
35.	Moving Contact
43.	Nut
79.	Bolt
80.	Washers
81.	Trip Knife
82.	Half Shaft
83.	Striker Nut
84.	Locknut
85.	Safety Screw
86.	Limit Screw
87.	Trip Lever
88.	Locknut
89.	Striker Nut
145.	Trip Drive Rod
153.	Reverse Trip Rod

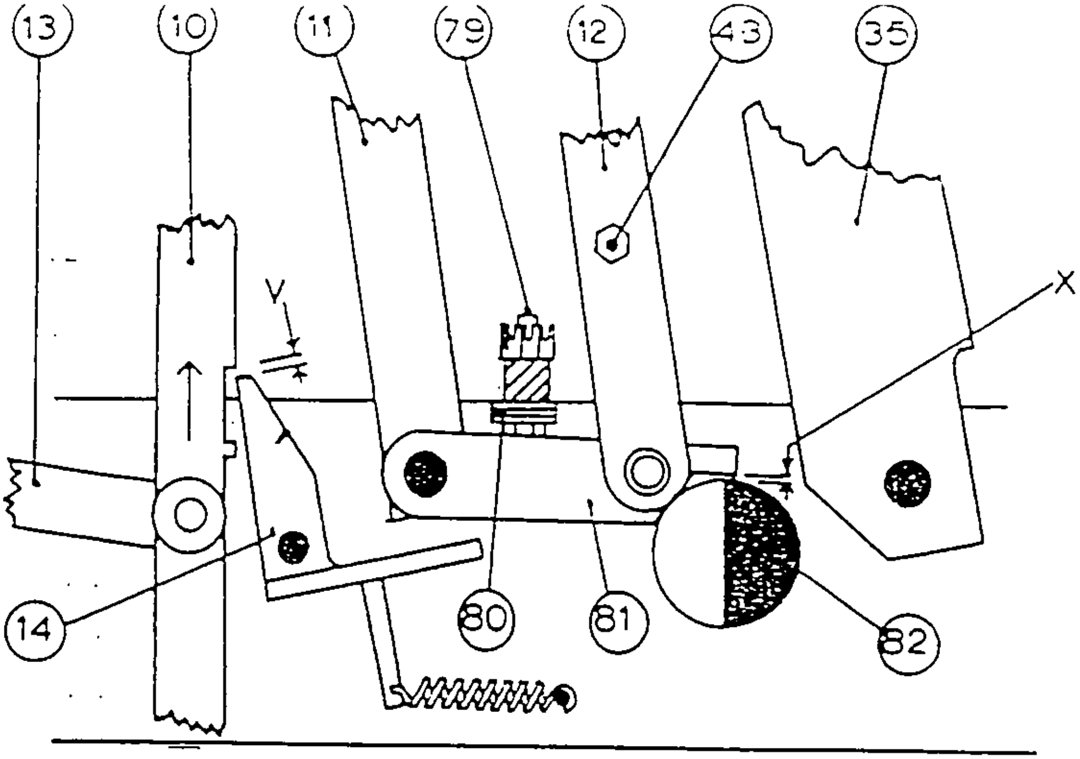


FIG1: HALF SHAFT AND LOWER MECHANISM

BREAKER FRONT PANEL

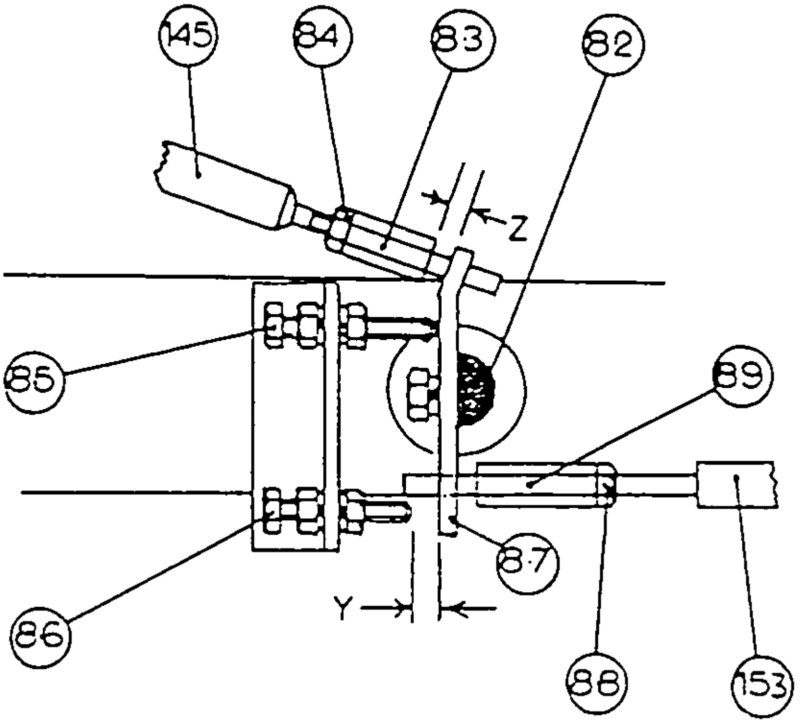
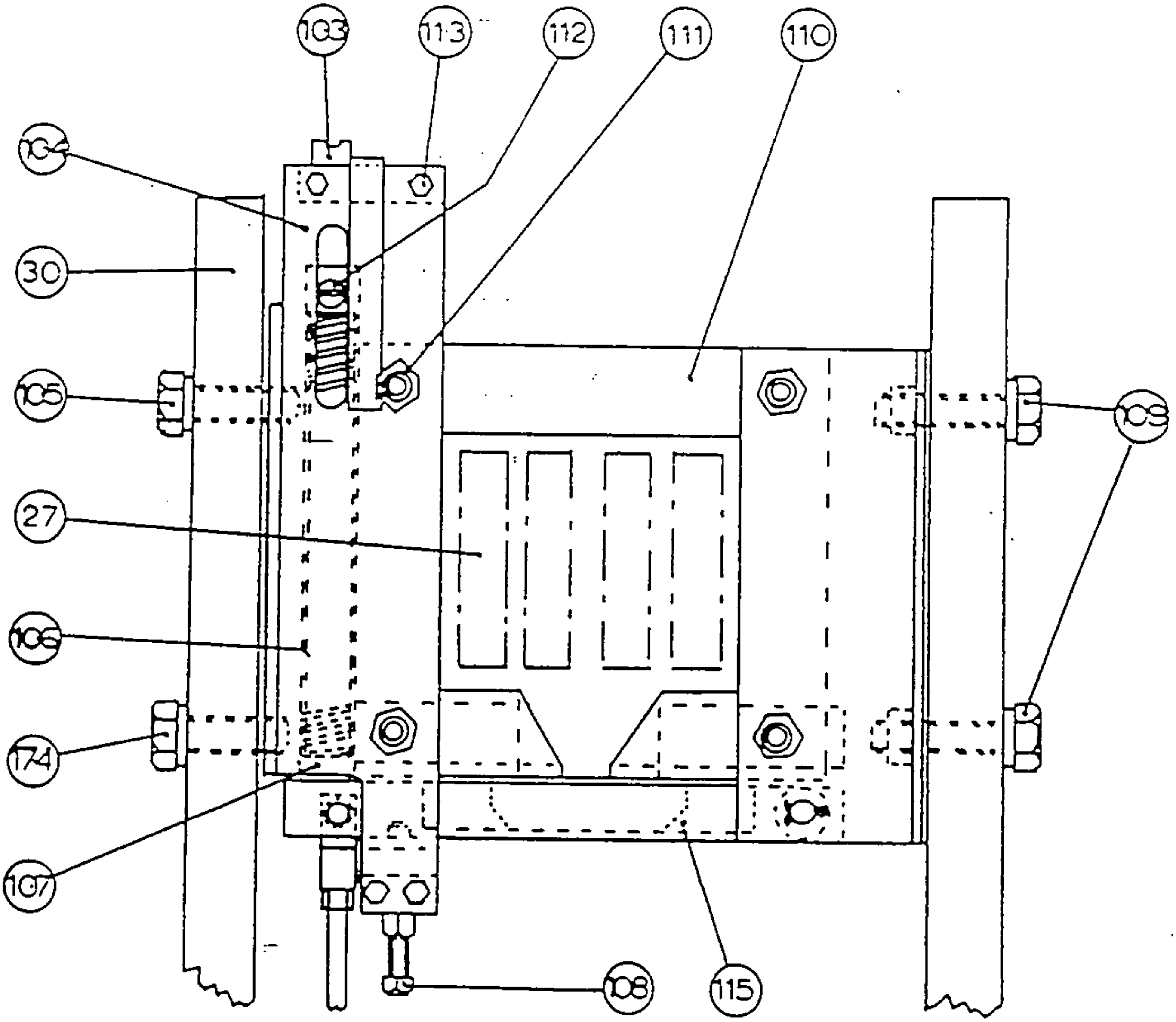


FIG2: HALF SHAFT AND TRIPPING LINKAGES

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778G

OVERLOAD UNIT

27.	Bottom Fixed Contact
30.	Breaker Side Panel
103.	Calibration Screw
104.	Support Bracket
105.	Screw
106.	Overload Springs
107.	Armature Pressure Plate
108.	Screw
109.	Screw
110.	Magnetic Yoke
111.	Nut
112.	Trunnion
113.	Screw
115.	Trip Armature
174.	Screw



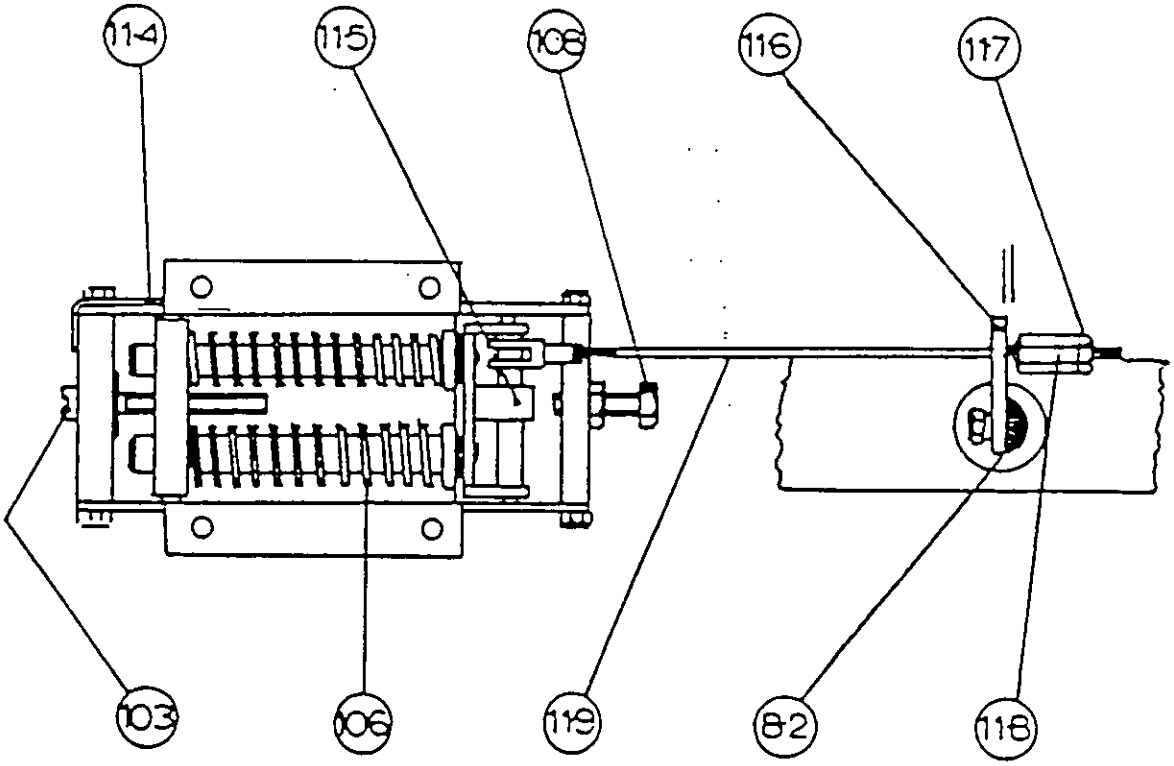
OVERLOAD UNIT

S778G

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778H

OVERLOAD UNIT AND TRIP LINKAGE

82.	Half Shaft
103.	Calibration Screw
106.	Overload Springs
108.	Screw
114.	Calibration Plate
115.	Trip Armature
116.	Trip Lever
117.	Adjusting Nut
118.	Striker Nut
119.	Overload Trip Rod



OVERLOAD UNIT AND TRIP LINKAGE

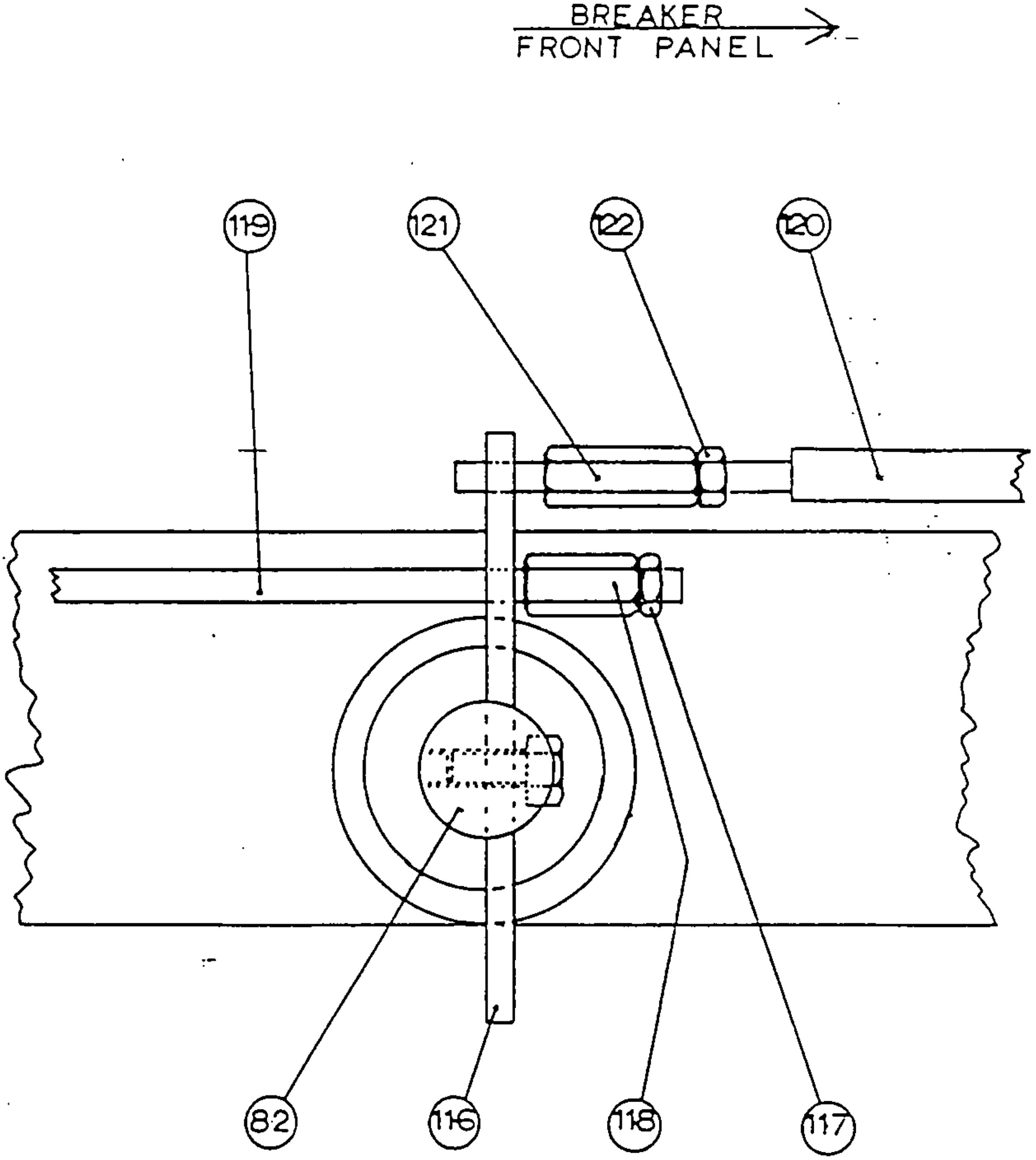
Viewed from Left Hand Side of C.B.

S778H

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778J

OVERLOAD AND UNDERVOLTAGE RELEASE OPERATING RODS

82.	Half Shaft
116.	Trip Lever
117.	Locknut
118.	Striker Nut
119.	Overload Operating Rod
120.	Undervoltage Release Operating Rod
121.	Striker Nut
122.	Locknut

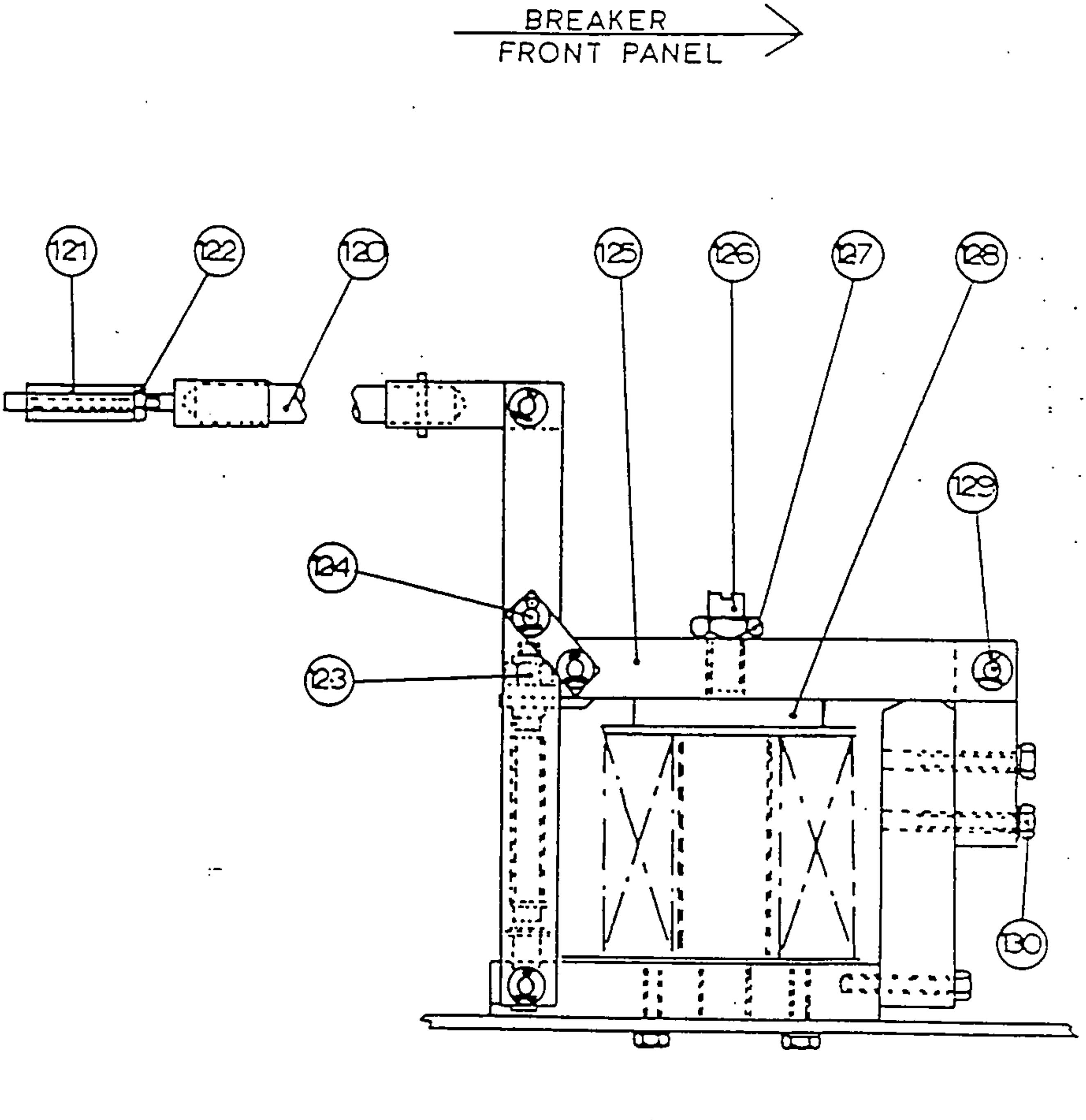


OVERLOAD AND UNDERVOLTAGE OPERATING RODS

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778K

UNDERVOLTAGE RELEASE

120. Undervoltage Release Operating Rod
121. Striker Nut
122. Adjusting Nut
123. Nut
124. Pin
125. Armature
126. Screw
127. Locknut
128. Core
129. Pin
130. Screws



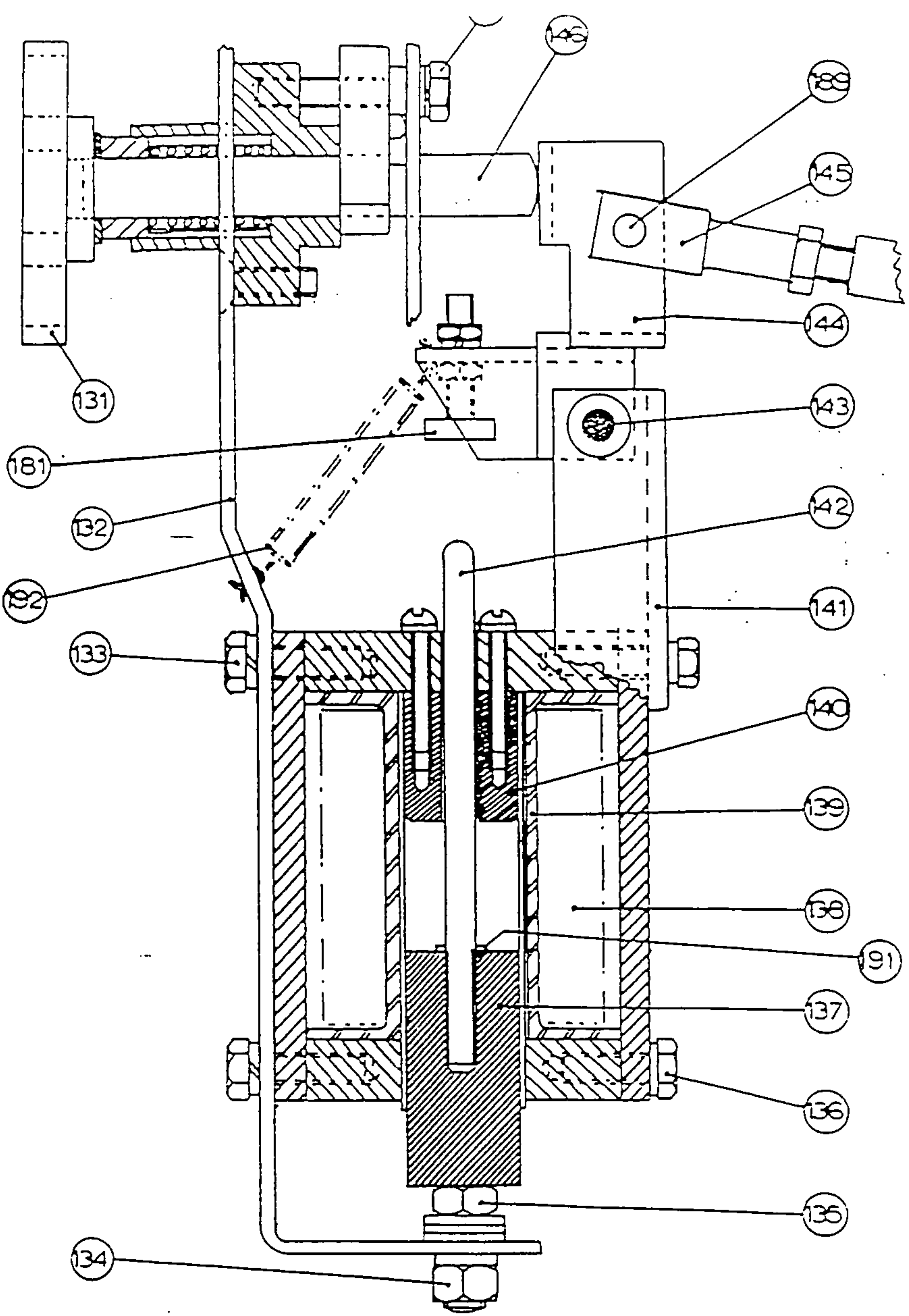
UNDERVOLTAGE RELEASE

S778K

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778L

SHUNT TRIP

131. Hand Trip Knob
132. Inner Panel
133. Screw
134. Nut
135. Screw
136. Screw
137. Moving Core
138. Shunt Trip Coil
139. Spool
140. Fixed Core
141. Support Bracket
142. Trip Poker
143. Pivot Pin
144. Trip Bracket
145. Clevis
146. Trip Shaft
181. Trip Button
189. Clevis Pin
190. Pivot Screw
191. Anti-cling Washer
192. Spring



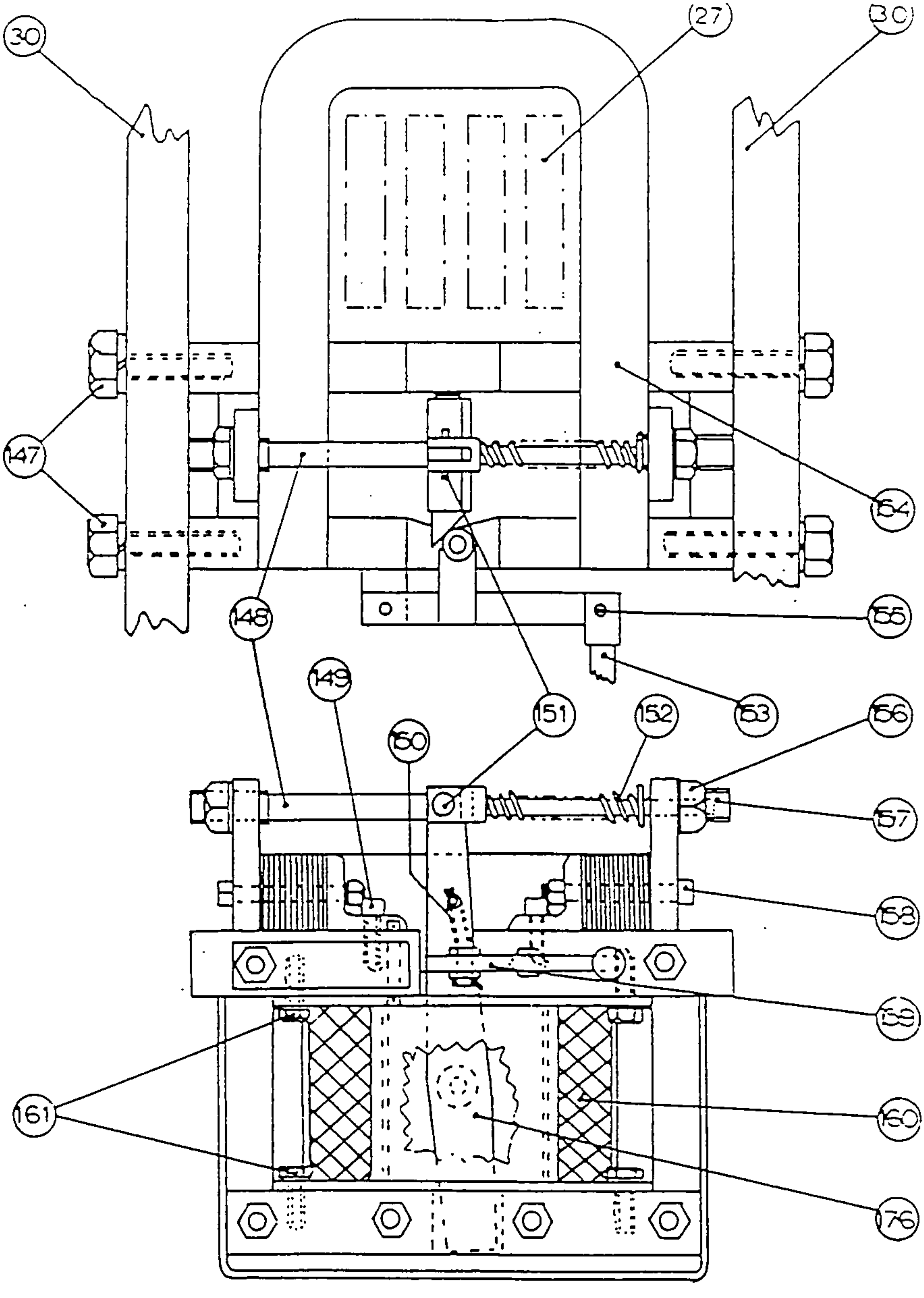
SHUNT TRIP

S778L

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778M

REVERSE UNIT

27.	Bottom Fixed Contact
30.	Breaker Side Panel
147.	Screw
148.	Stop Screw
149.	Socket Screw
150.	Re-set Spring
151.	Clevis Pin
152.	Return Spring
153.	Reverse Trip Rod
154.	Yoke
155.	Clevis Pin
156.	Nut
157.	Spring Adjuster
158.	Screw
159.	Link
160.	Coil
161.	Screw
176.	Trip Armature



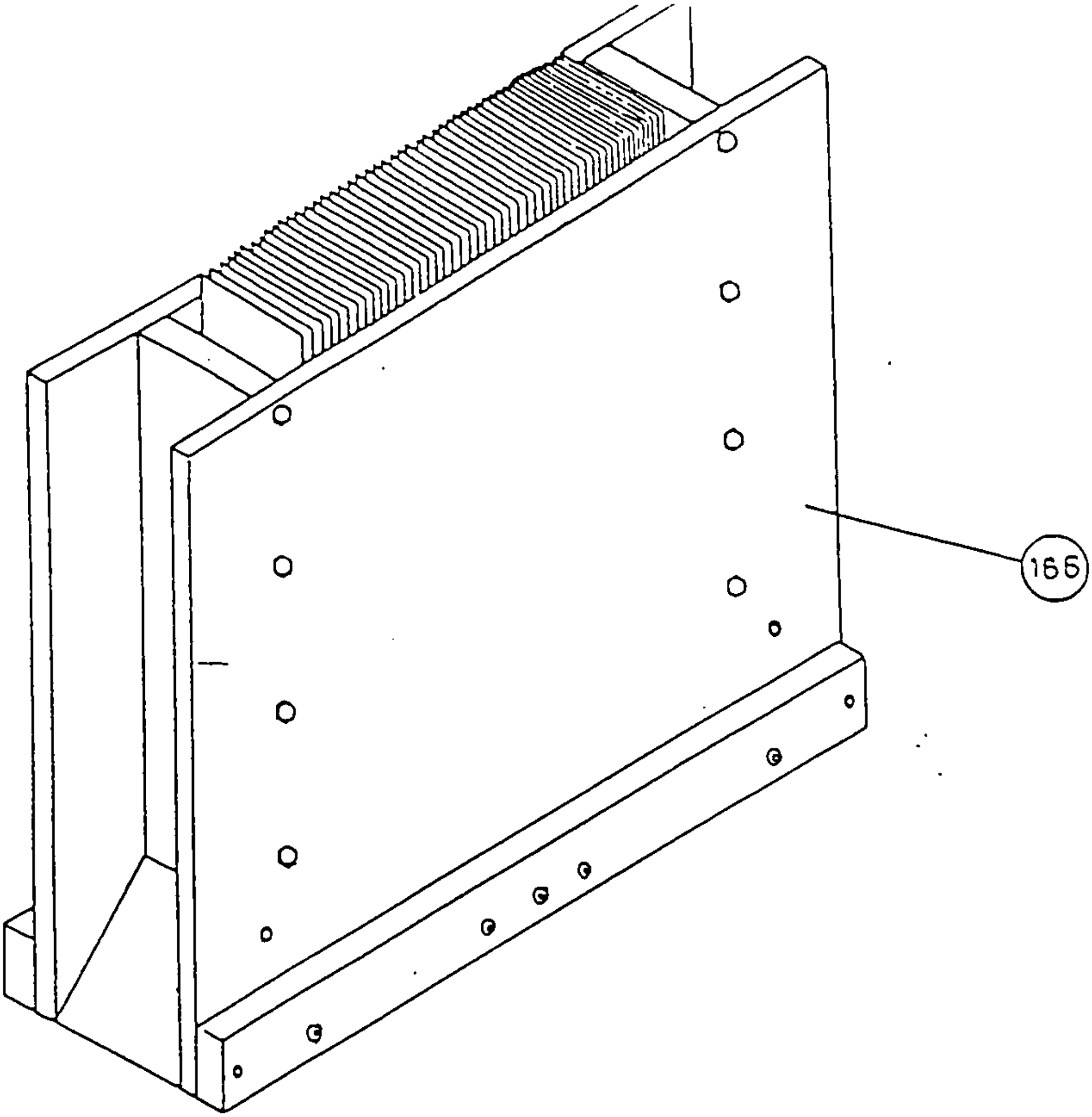
REVERSE UNIT

S778M

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778N

ARC CHUTE

166. Arc Chute



ARC CHUTE

S778N

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778P

FIGURE 1 - L.T. CONTACTS

FIGURE 2 - OPENING SPRING AND MECHANISM ADJUSTMENT

6.	Opening Spring
7.	Mechanism Adjustment Bracket
8.	Mechanism Adjustment Shims
170.	Insulated Base
171.	Spring Contact
177.	Spring Block
178.	Nut
179.	Bolt
180.	Spring Retainer
193.	Spacer

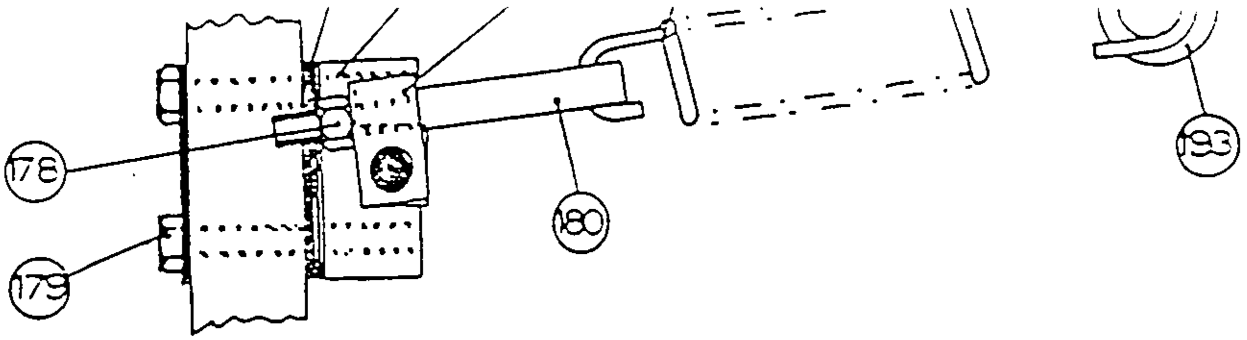


FIG 2 OPENING SPRING AND MECHANISM ADJUSTMENT

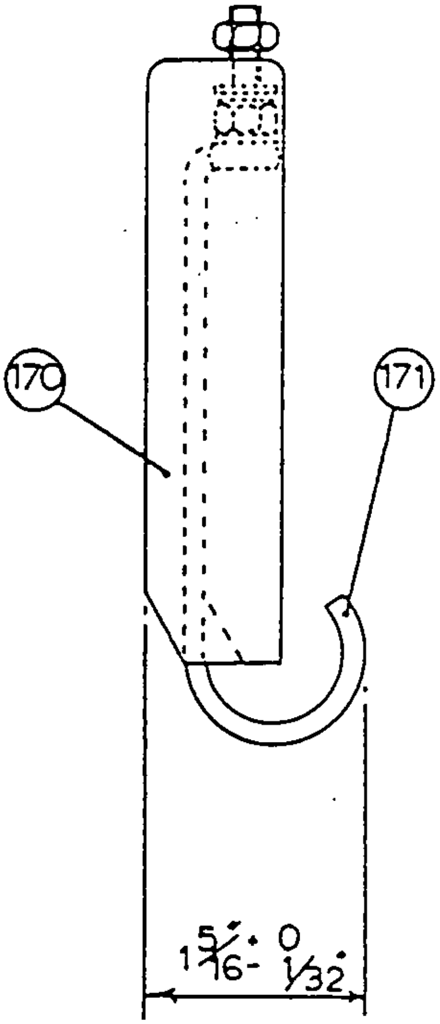
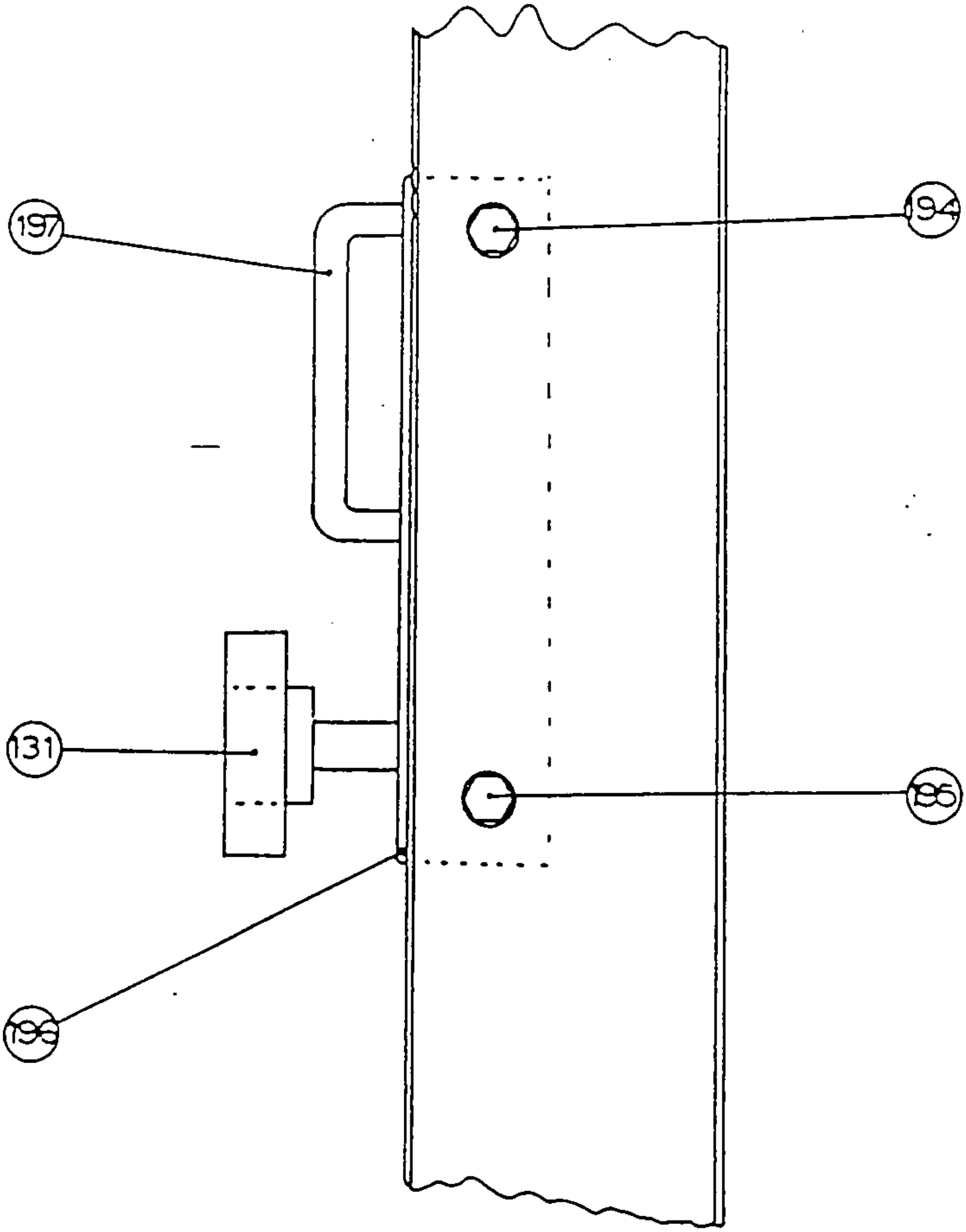


FIG 1 L.T. CONTACTS

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778Q

SUB-PANEL

131.	Hand Trip Knob
194.	Bolt
195.	Bolt
196.	Sub-Panel
197.	Manoeuvering Handle



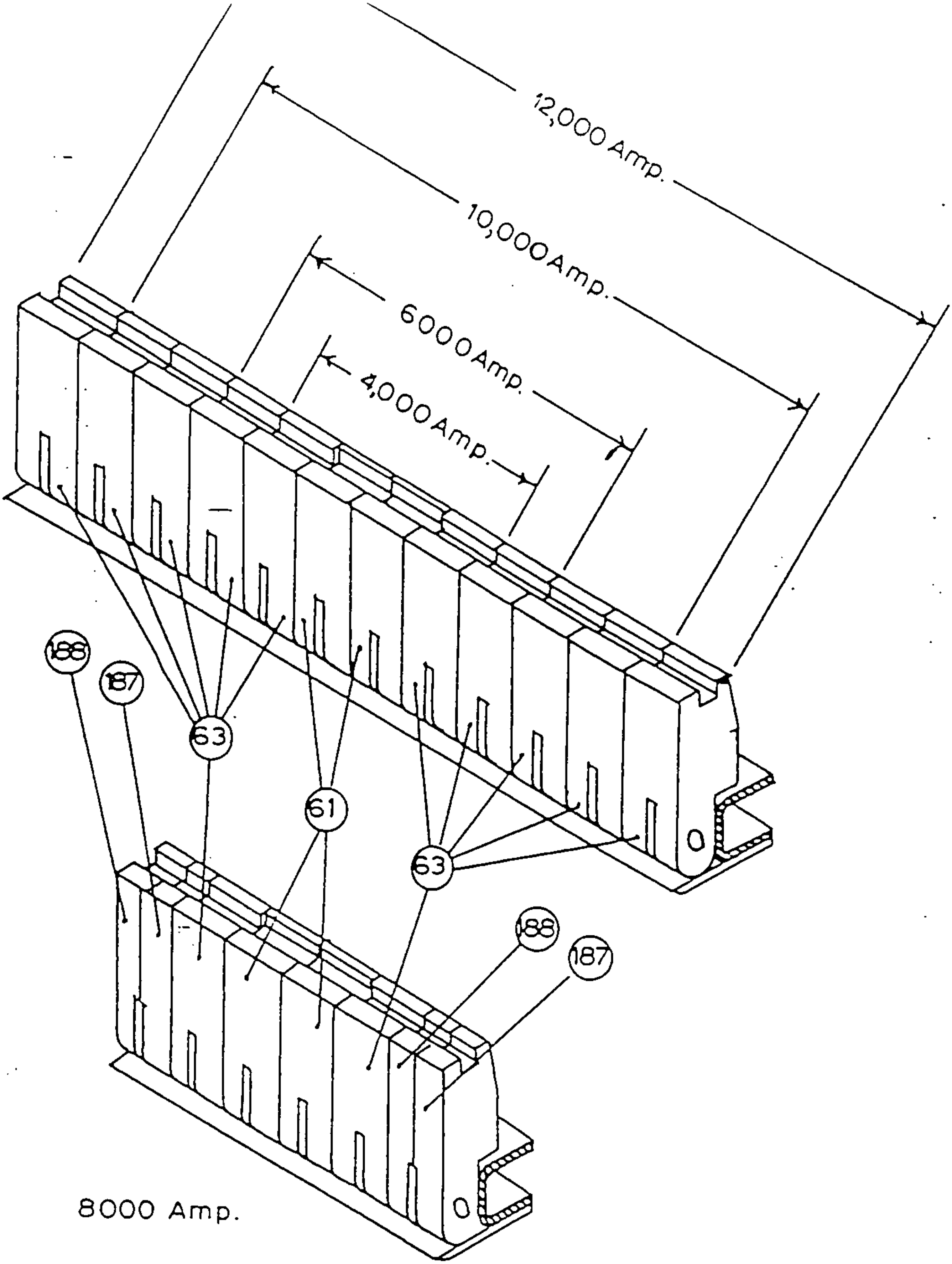
SUB - PANEL

S778Q

KEY TO COMPONENT NUMBERS ON ILLUSTRATION S778R

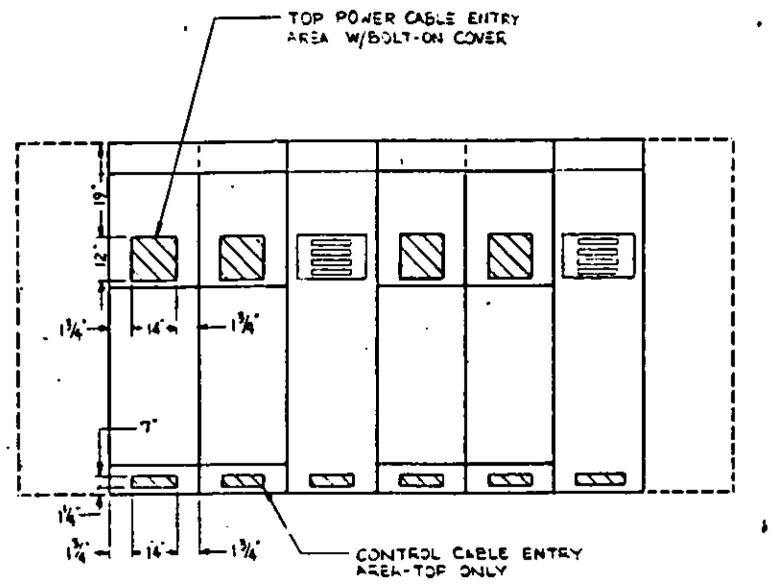
BOTTOM CONTACT ASSEMBLIES

61.	Advanced Contact Finger
63.	Contact Finger
187.	L.H. Half Contact Finger
188.	R.H. Half Contact Finger

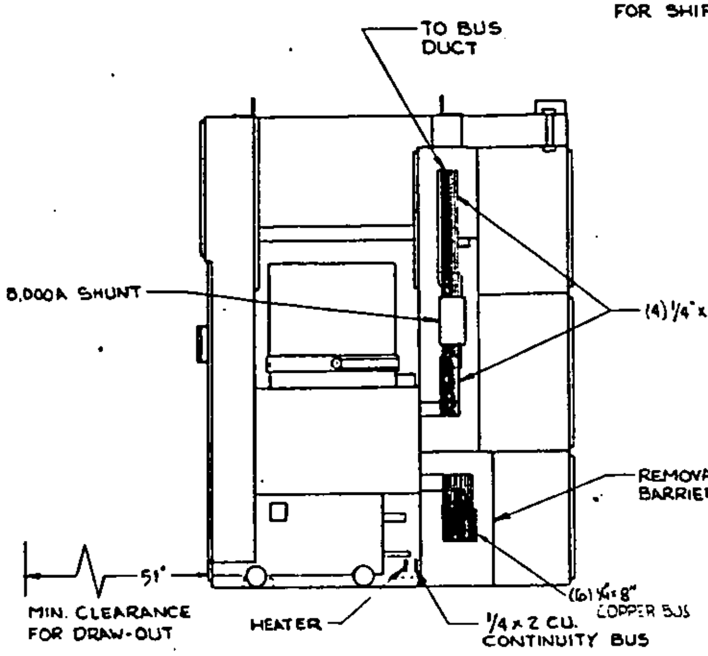


BOTTOM CONTACT ASSEMBLIES

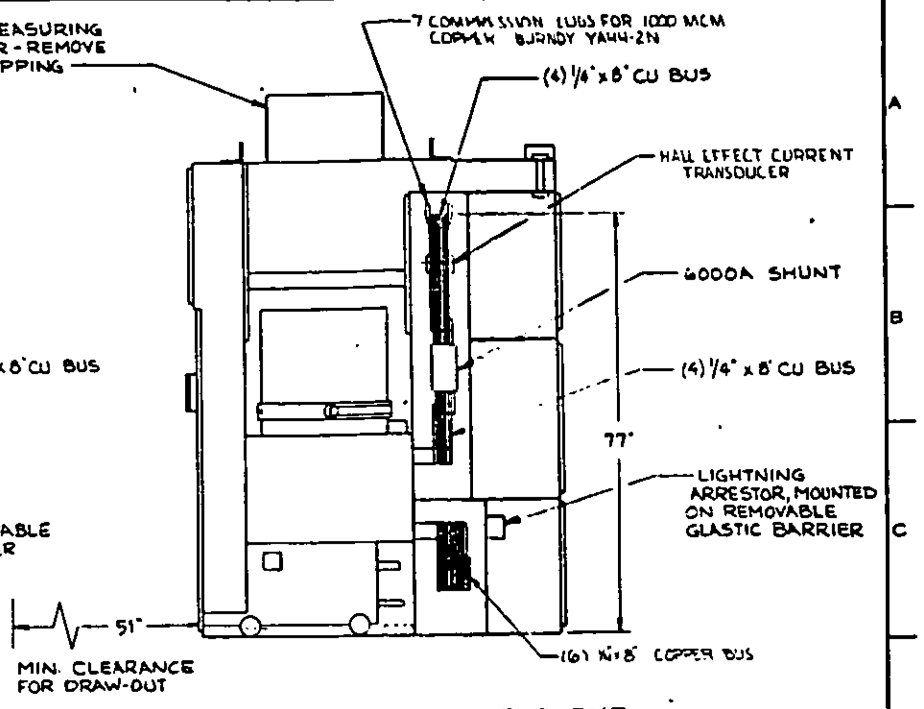
S778R



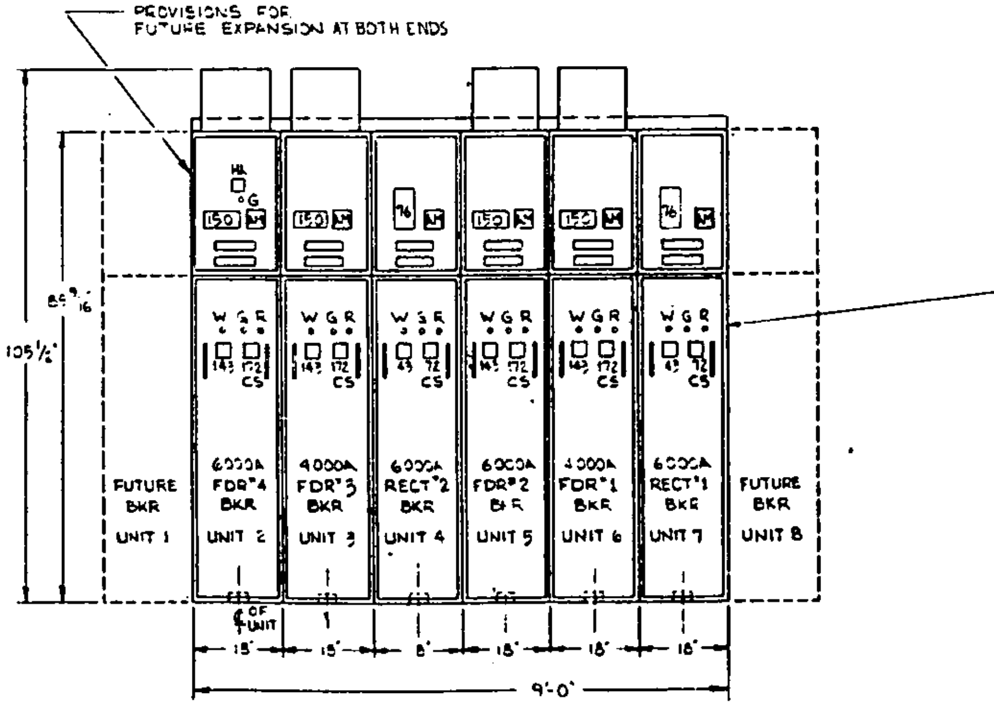
PLAN VIEW



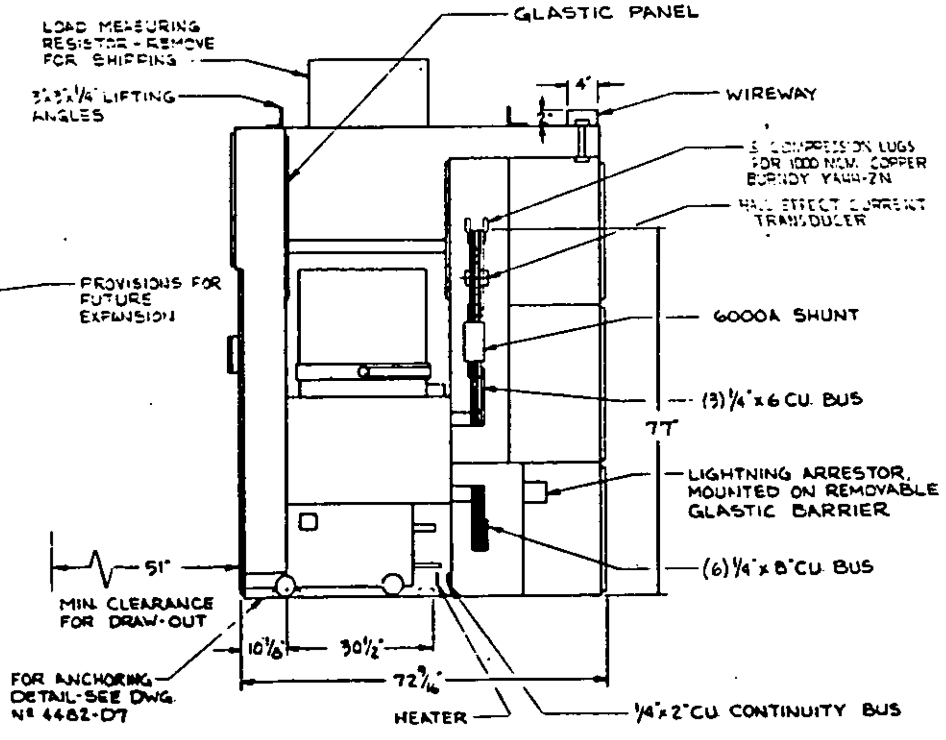
SECTION VIEW OF 6000A RECT. BKR.



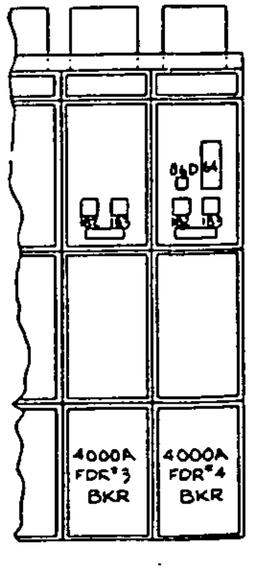
SECTION VIEW OF 6000A FDR. BKR.



FRONT VIEW



SECTION VIEW OF 4000A FEEDER BKR



REAR VIEW
FOR COMPLETE REAR VIEW
SEE DWG. Nº 4482-C 109

LEGEND

172CS - BKR CONTROL SWITCH (FDR)
W - WHITE LIGHT
G - GREEN LIGHT
R - RED LIGHT
AM - AMMETER
64 - HIGH RESISTANCE GND. RELAY
86D - LOCKOUT RELAY, SUBSTATION
143 - REMOTE/LOCAL SWITCH (FDR)
150 - RATE OF RISE RELAY
182 - CURRENT LOAD MEASURING RELAY
183 - VOLTAGE LOAD MEASURING RELAY
72CS - BKR CONTROL SWITCH (RECT.)
43 - REMOTE/LOCAL SWITCH (RECT.)
HA - HEATER AMMETER
76 - FORWARD CURRENT TRIP DEVICE

FINISH - LIGHT GRAY NO. 61 ANSI Z 55.1
MINIMUM OF 2 MILS THK

WEIGHT -
SWITCHGEAR - 7,200 lbs
BREAKERS (EA.) - 650 lbs
TOTAL - 11,100 lbs

2	DLG	4-12-90	Rev UNIT 2 TO A 6000 AMP BKR WAS 4000 AMP.

REV 2

MICRO FILMED 4-14-92

PLE
5-20-89

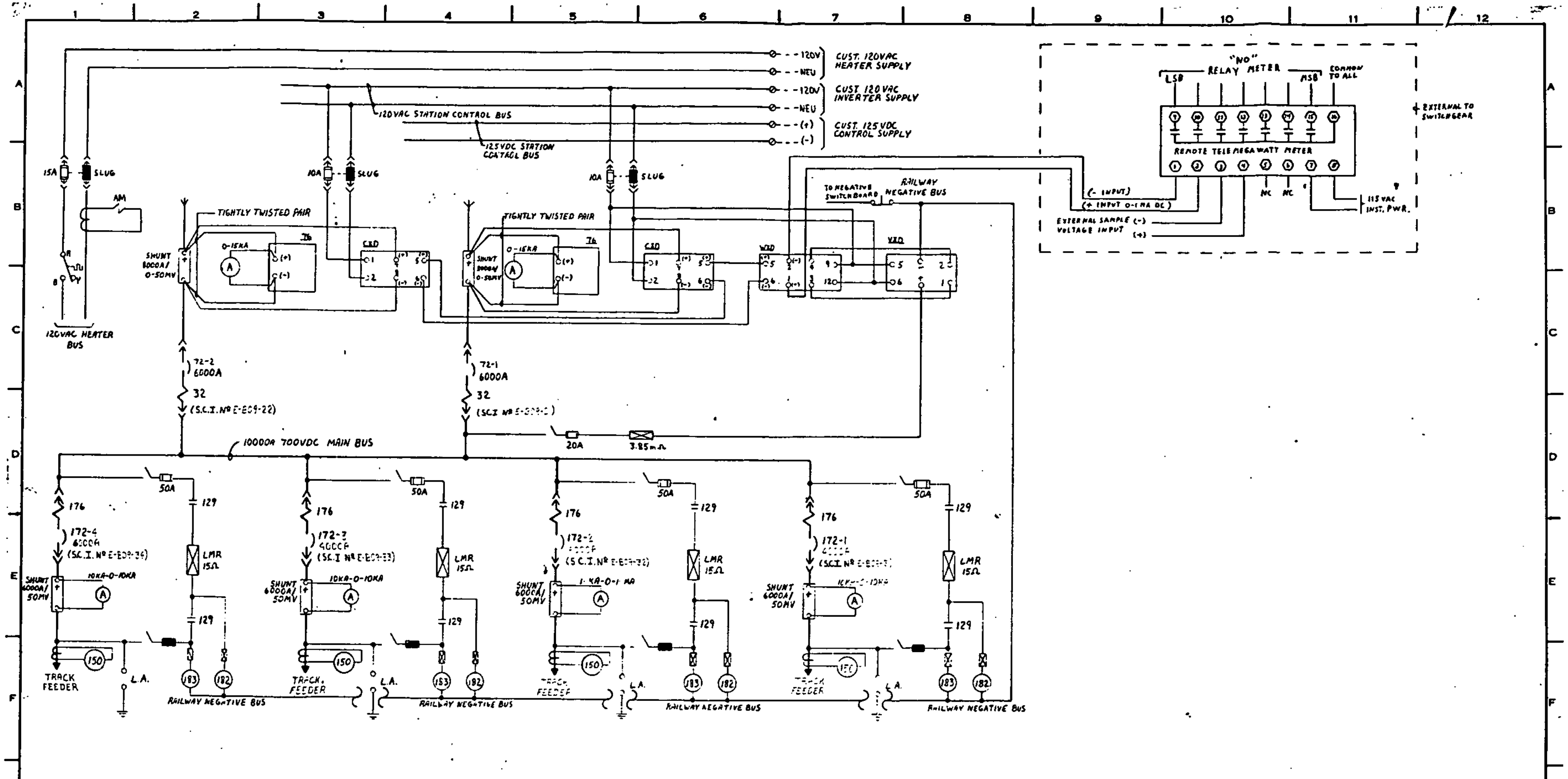
CONTROLLED POWER CORP.

WMATA/65-9
CONTRACT # 181049
KINGSTON CONTRACTORS

ELEVATION OF
SUBSTATION EQUIPMENT SS-9
TRACTION POWER SUBSTATION
LANDSDOWNE WAY
- D.C. SWITCHGEAR

4482-D12

MAY 25 1990



NOTES:
FOR DEVICE LEGEND SEE 4982-A1
FOR DRAWING REFERENCE SHEET, SEE 4982-B2

1	REV. 172-4 BKR. SIZE	4/4/90	BKM

MICRO FILMED 6-14-90

J.F.K.
5-19-88
UN

CONTROLLED POWER CORP

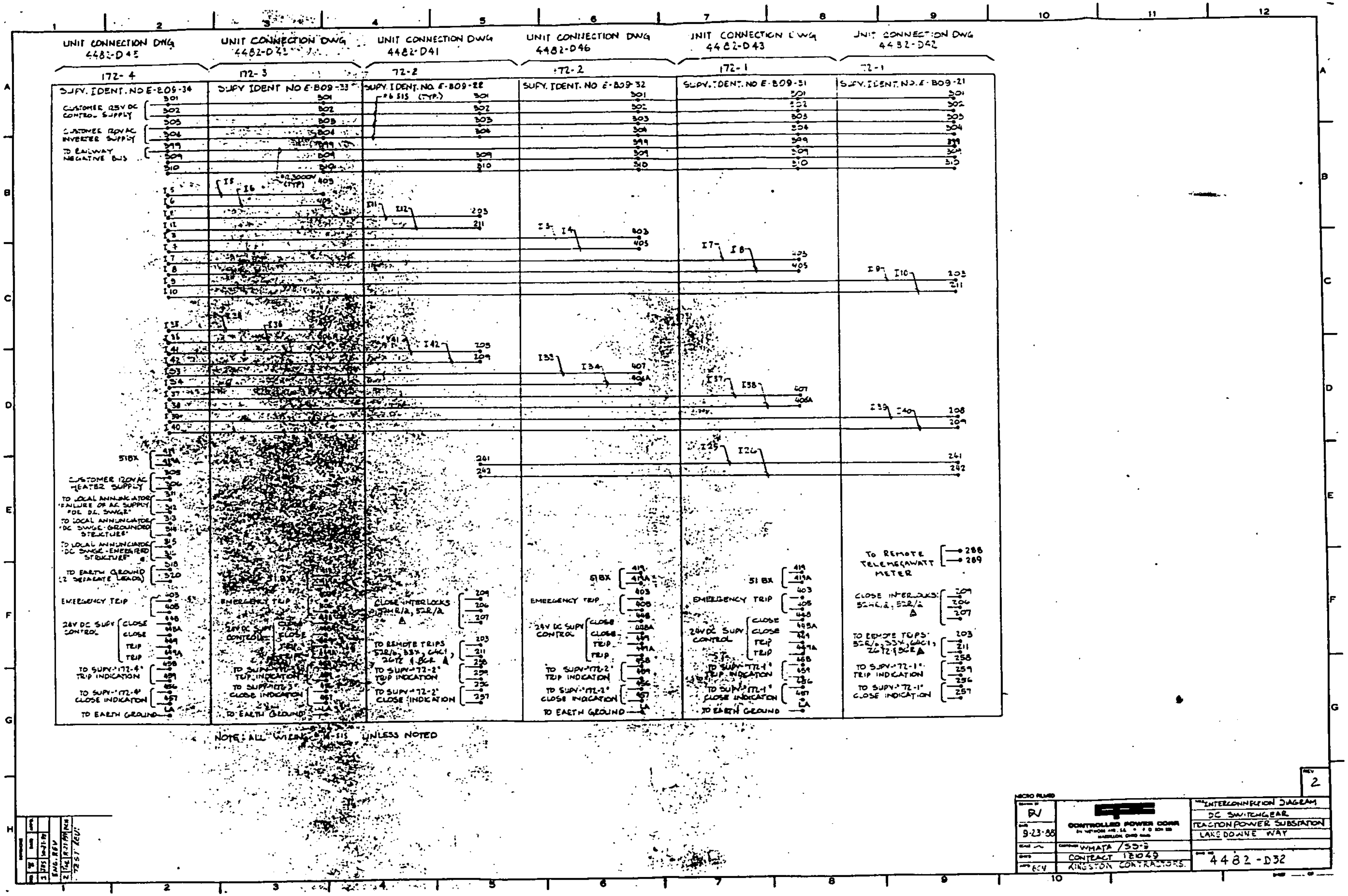
WMATA/SS-9
CONTRACT 1E1049
KINGSTON CONTRACTORS

POWER DIAGRAM
D.C. SWITCHGEAR
TRACTION POWER SUBSTATION
LANSDOWNE WAY

4482-D22

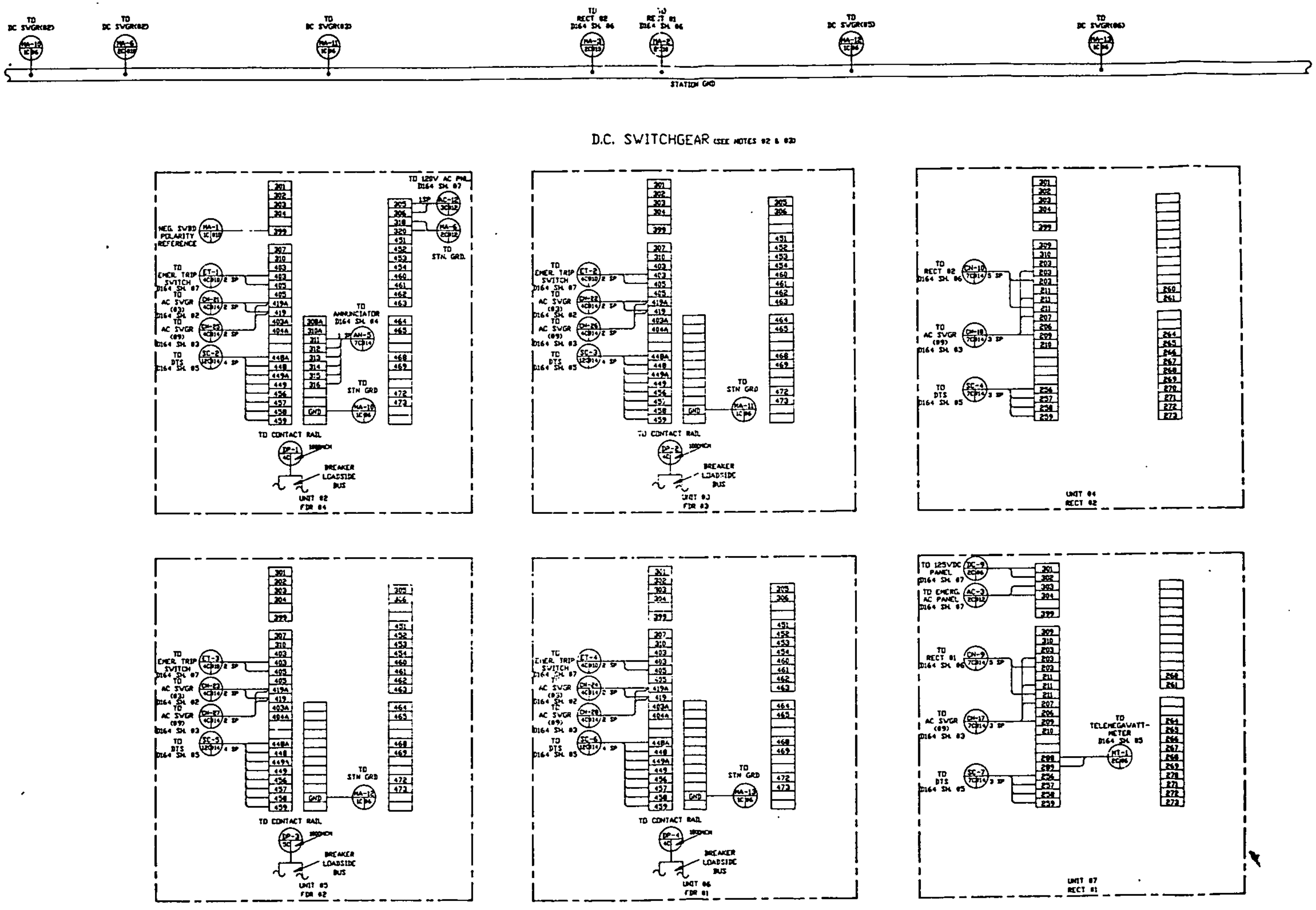
REV. 1

MAY 2 5 1990



MAY 25 1990

MAY 25 1990



REVISIONS		
NO	BY	DATE
1	JMS	08/04/89

CUST. REV'S MA-1 AC-12

MICROFILMED 9-18-89

NOTES:
1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-15, SS9-E-16, SS9-E-17, SS9-E-18 SS9-E-19, SS9-E-20, SS9-E-21, SS9-E-22, SS9-E-23, SS9-E-72
2. ALL CUSTOMER CONNECTION TO D.C. SWITCHGEAR MADE ON FRONT METERING COMPARTMENT TERMINAL BLOCKS. (WITH EXCEPTION OF POWER CABLE CONNECTIONS)
3. SPARE TERMINALS IN DC SWITCHGEAR ARE SHOWN AS BLANKS

DRAWN BY MRS
DATE 3/16/89
SCALE NTS
CHK'D.
APP'D.

CONTROLLED POWER CORP.

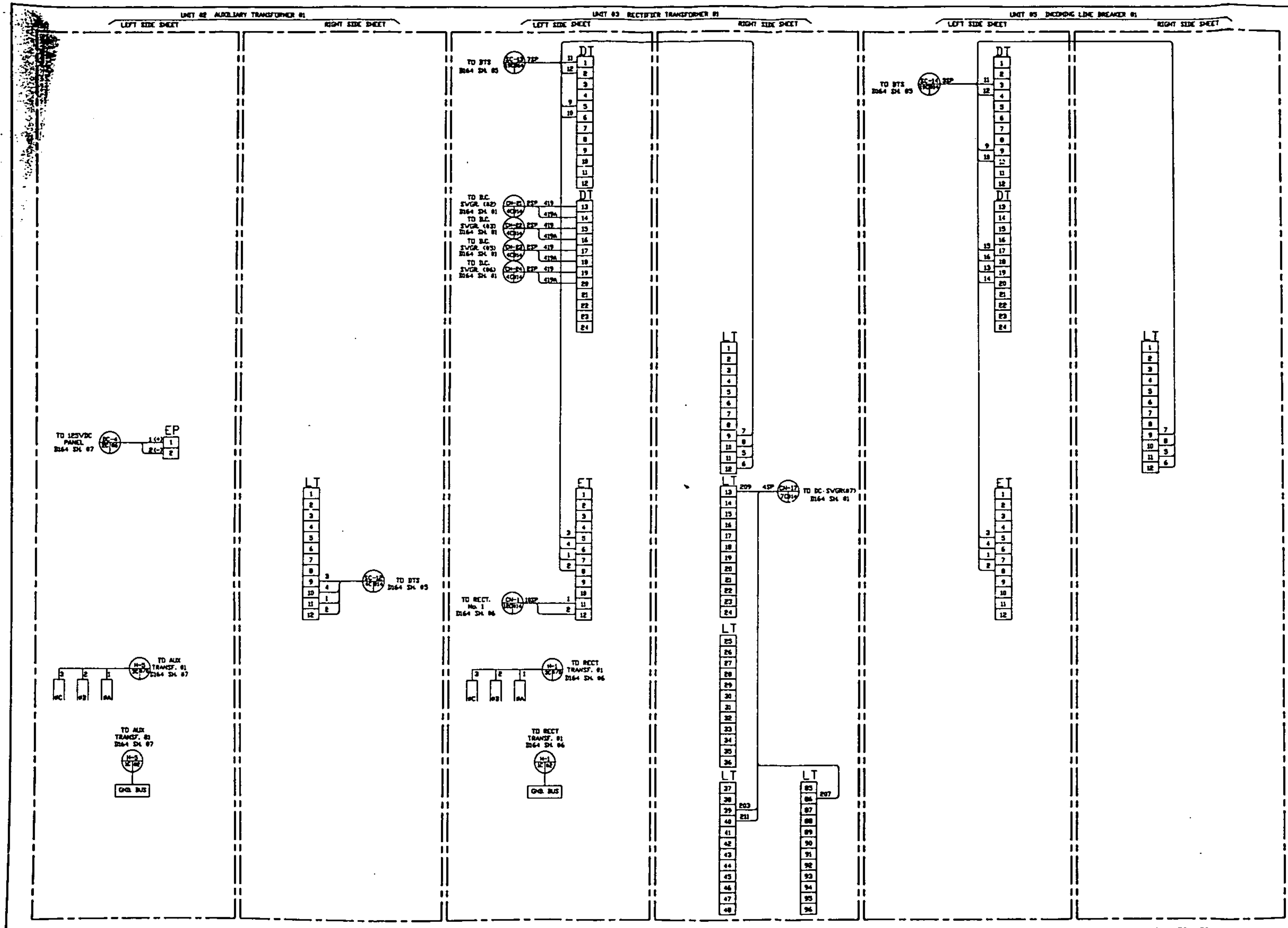
CUST. WMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE EQUIPMENT INTERCONNECTIONS FOR LANDSDOWNE WAY SUBSTATION

REV 1

DWG. NO. 4482-D164
SHEET 1 OF 7

MAY 25 1990



REVISIONS

NO.	BY	DATE

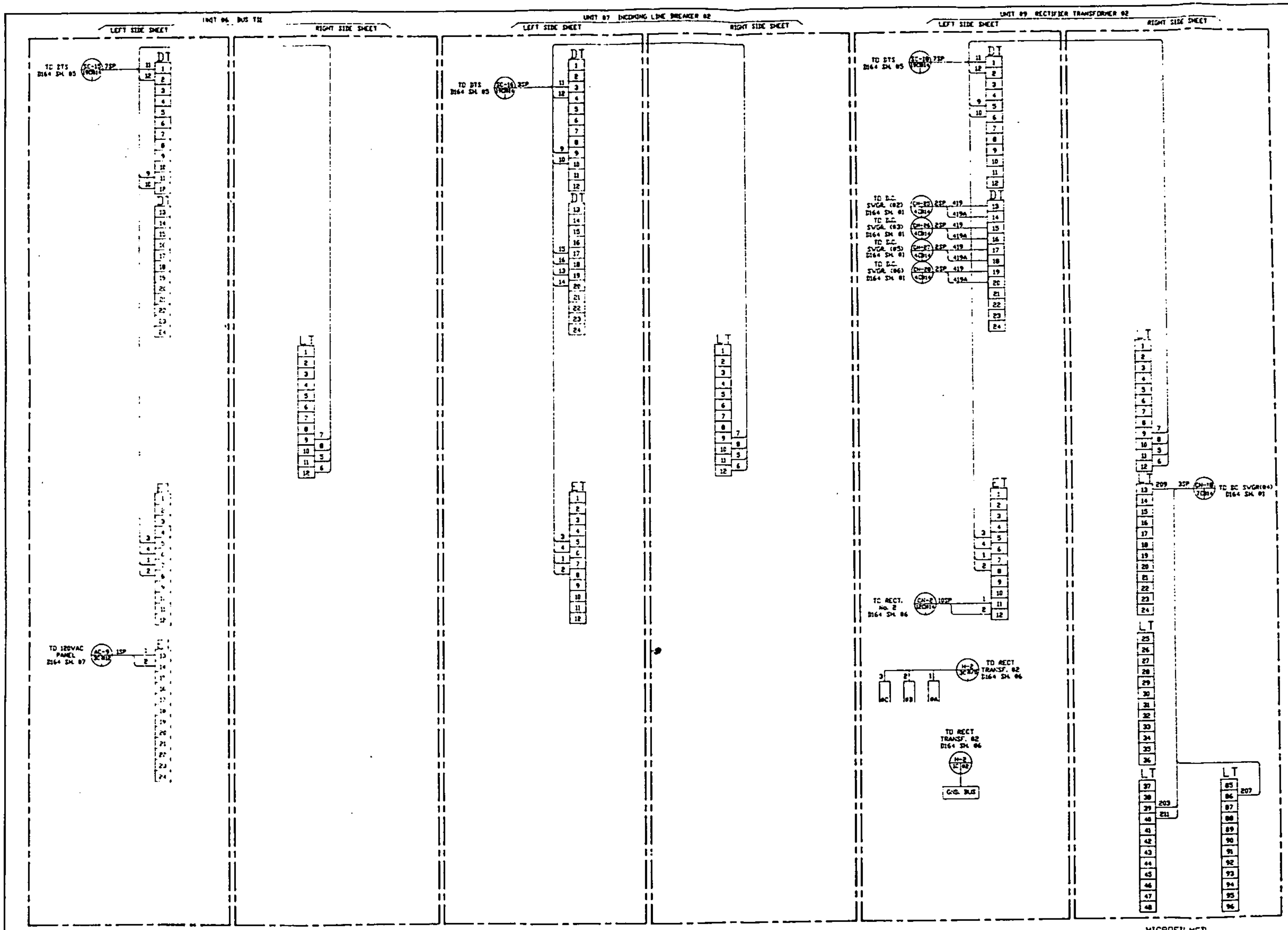
NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-15, SS9-E-16, SS9-E-17, SS9-E-18, SS9-E-19, SS9-E-20, SS9-E-21, SS9-E-22, SS9-E-23, SS9-E-72.

MICROFILMED

DRAWN BY MRS	[redacted] CONTROLLED POWER CORP.	TITLE EQUIPTMENT INTERCONNECTIONS FOR LANSDOWNE WAY SUBSTATION	REV
DATE 3/17/89			
SCALE NTS	CUST. WMATA/SS-9		
CHK'D.	CONTRACT #1Z1049	DWG. NO. 4482-D164 SHEET 2 OF 7	
APP'D. AS	KINGSTON CONTRACTORS		

MAY 25 1990



MICROFILMED

NOTES:
1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-15, SS9-E-16, SS9-E-17, SS9-E-18, SS9-E-19, SS9-E-20, SS9-E-21, SS9-E-22, SS9-E-23, SS9-E-72

REVISIONS		
NO	BY	DATE
1	JMS	8/04/89
CUST. REV'E AC-9		

DRAWN BY MRS
DATE 3/17/89
SCALE NTS
CHK'D.
APP'D.

CONTROLLED POWER CORP.

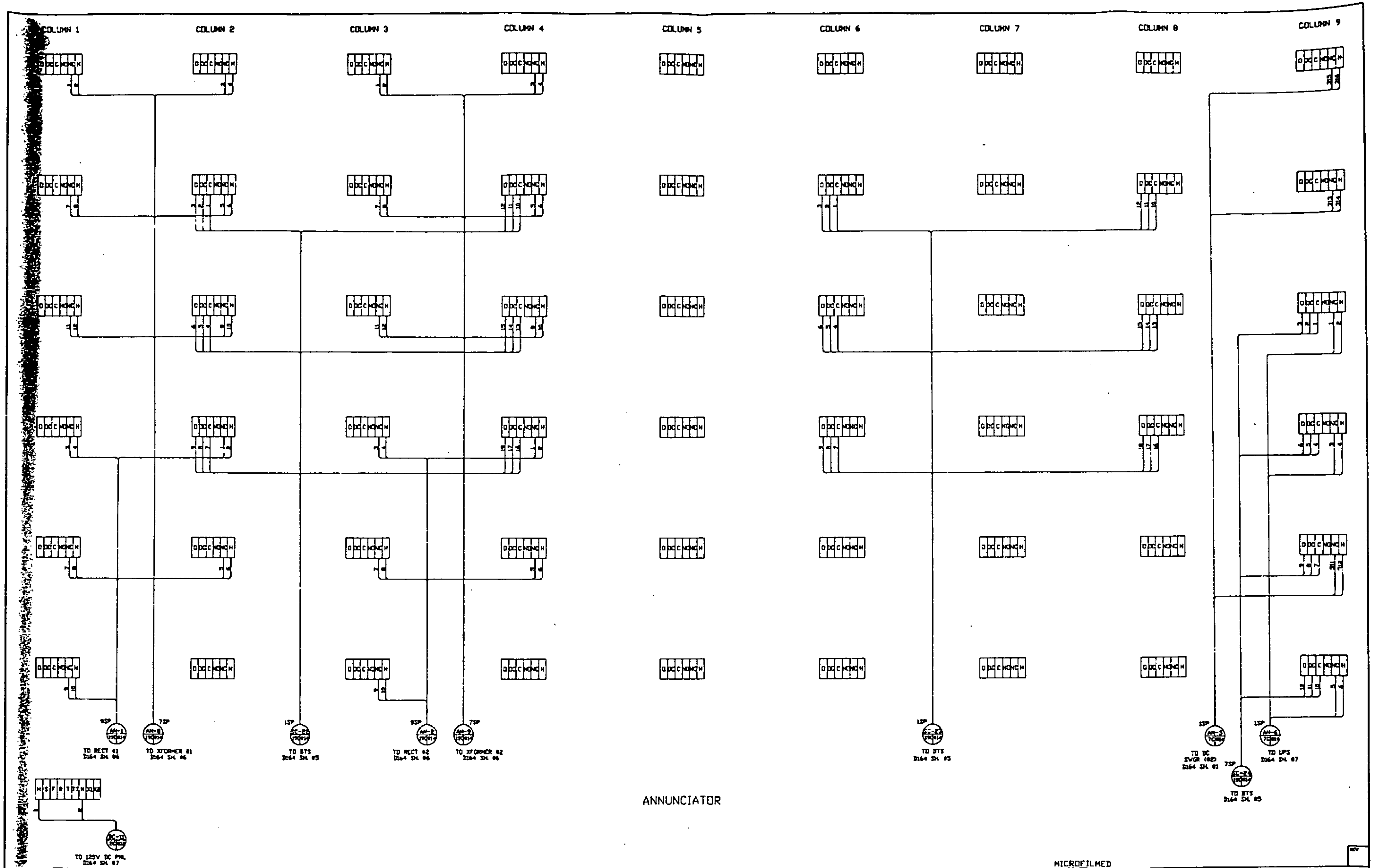
CUST. WMATA/SS-9
CONTRACT #121049
KINGSTON CONTRACTORS

TITLE EQUIPTMENT INTERCONNECTIONS FOR LANSDOWNE WAY SUBSTATION

DWG. NO. 4482-D164
SHEET 3 OF 7

REV 1

MAY 2 5 1990



REVISIONS
NO. BY DATE

NOTES:

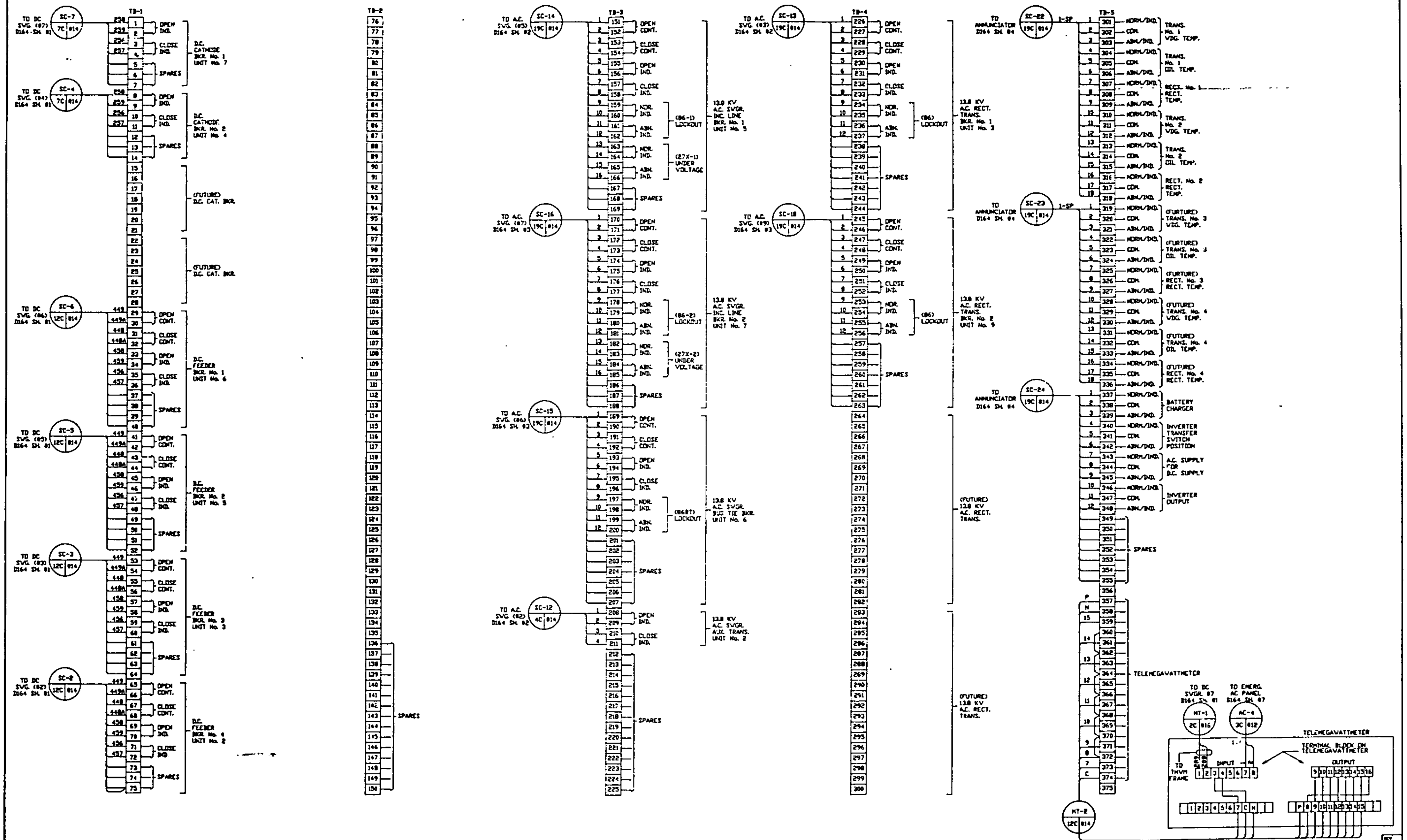
1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-15, SS9-E-16, SS9-E-17, SS9-E-18, SS9-E-19, SS9-E-20, SS9-E-21, SS9-E-22, SS9-E-23, SS9-E-72.

MICROFILMED

DRAWN BY R.R.R.	[redacted] CONTROLLED POWER CORP.	TITLE EQUIPMENT INTERCONNEC- IONS FOR LANSDOWNE WAY SUBSTATION
DATE 3/17/89		
SCALE NTS	CUST. WMATA/SS-9	
CHK'D.	CONTRACT #1Z1049	DWG. NO. 4482-D164 SHEET 4 OF 7
APP'D.	KINGSTON CONTRACTORS	

REV

MAY 25 1990



MICROFILMED 9-9-89

REVISIONS		
NO	BY	DATE
1	MES	8/11/89

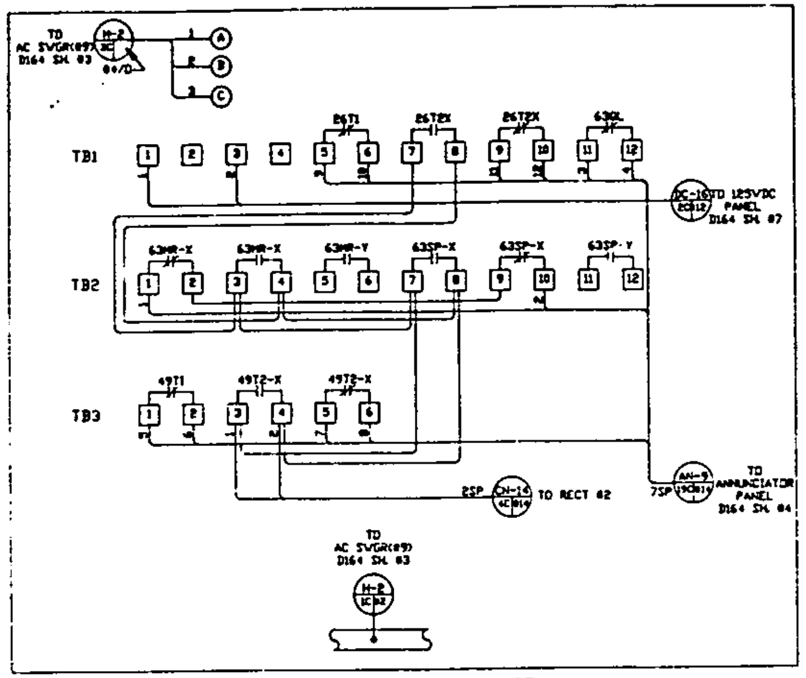
REVISED TERM. BLOCK ARRANGEMENT AT TELEMEGAWATTMETER PER TEST REVISION.

NOTES:
1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-15, SS9-E-16, SS9-E-17, SS9-E-18, SS9-E-19, SS9-E-20, SS9-E-21, SS9-E-22, SS9-E-23, SS9-E-72

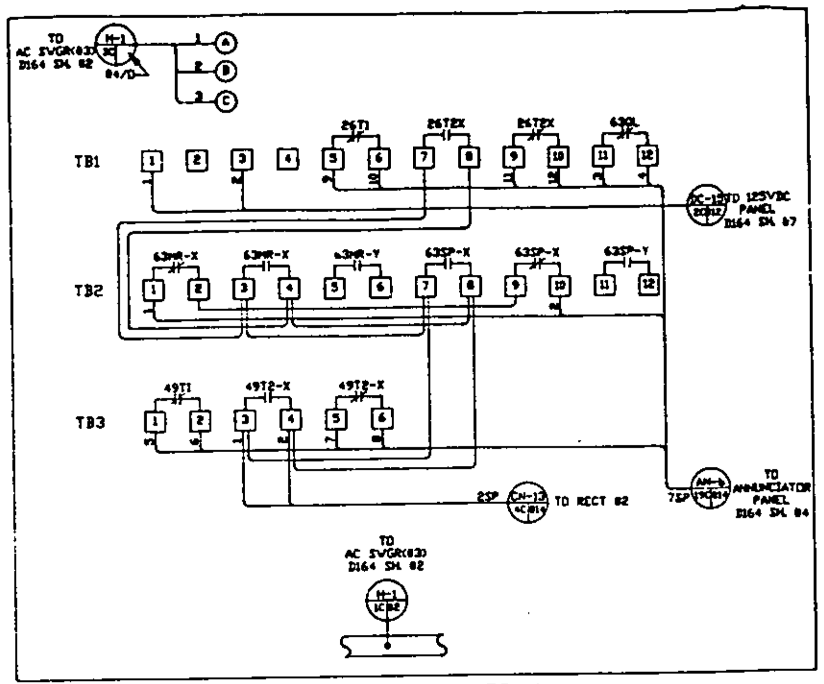
DRAWN BY J.H.S.	CONTROLLED POWER CORP.	TITLE EQUIPMENT INTERCONNECTIONS FOR LANSDOWNE WAY SUBSTATION
DATE 03/17/89		
SCALE NTS	CUST. WMATA/SS-9	
CHK'D.	CONTRACT #1Z1049	DWG. NO. 4482-D164 SHEET 5 OF 7
APP'D.	KINGSTON CONTRACTORS	

REV 1

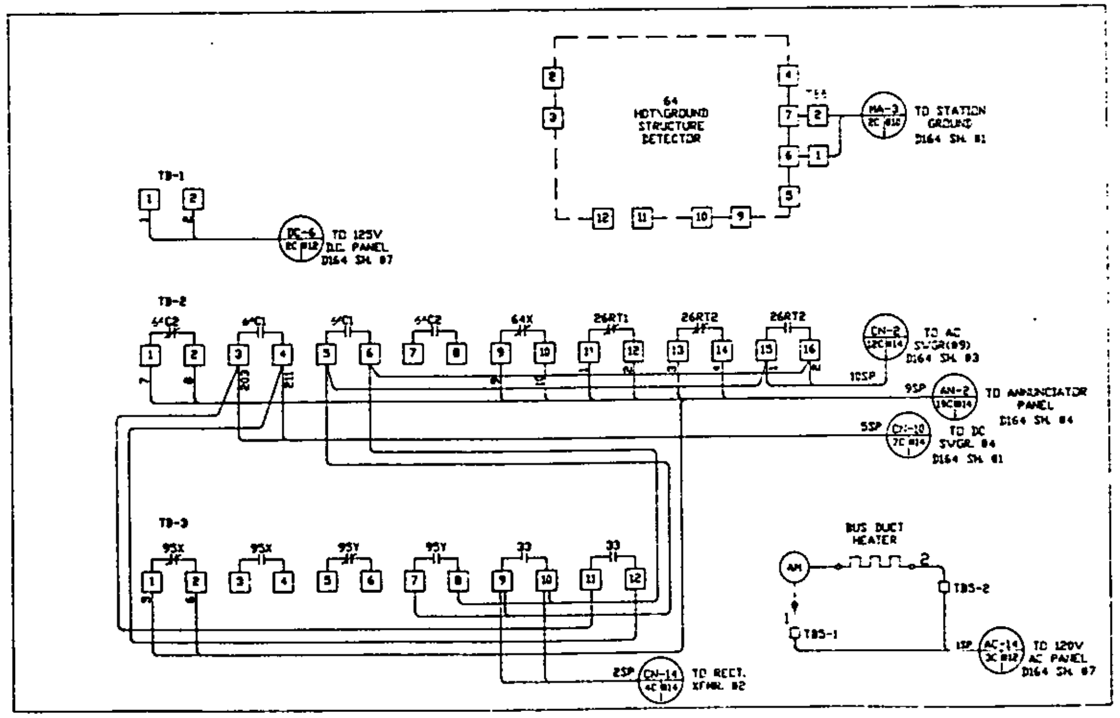
MAY 2 5 1990



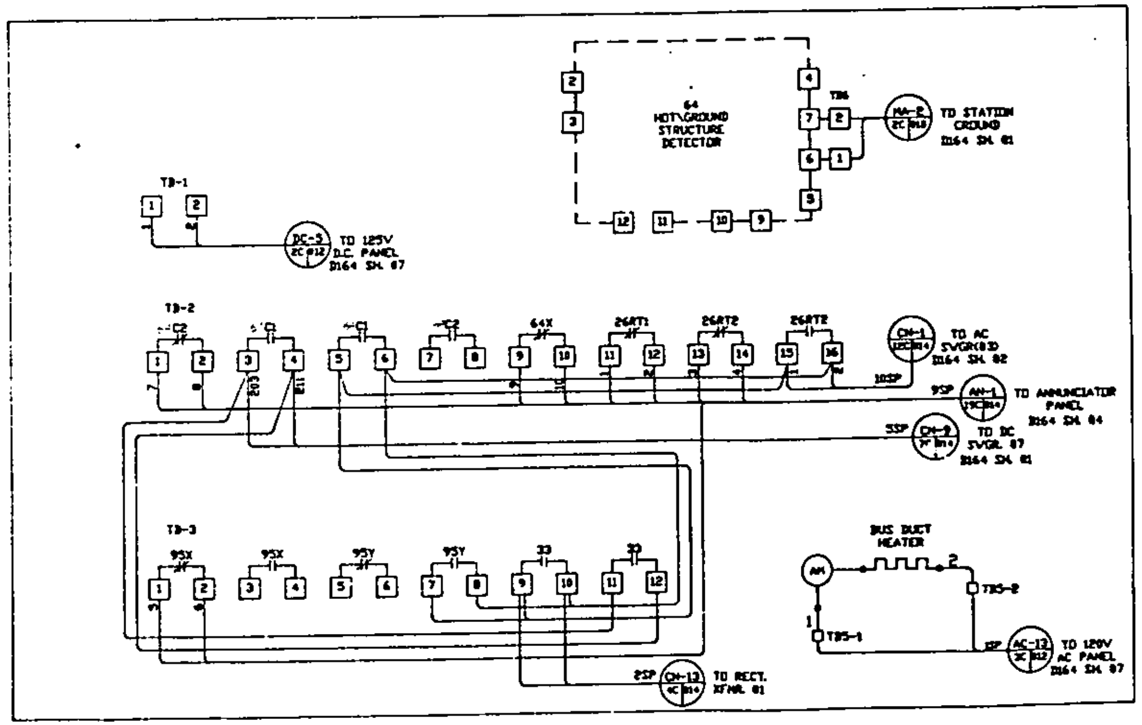
RECTIFIER TRANSFORMER #2



RECTIFIER TRANSFORMER #1



RECTIFIER #2



RECTIFIER #1

REVISIONS			
NO	BY	DATE	
1	JAS	8/10/89	TEST REVISIONS

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-15, SS9-E-16, SS9-E-17, SS9-E-18, SS9-E-19, SS9-E-20, SS9-E-21, SS9-E-22, SS9-E-23, SS9-E-72

MICROFILMED 9-18-89

DRAWN BY MRS
DATE 3/17/89
SCALE NTS
CHK'D.
APP'D.

CONTROLLED POWER CORP.

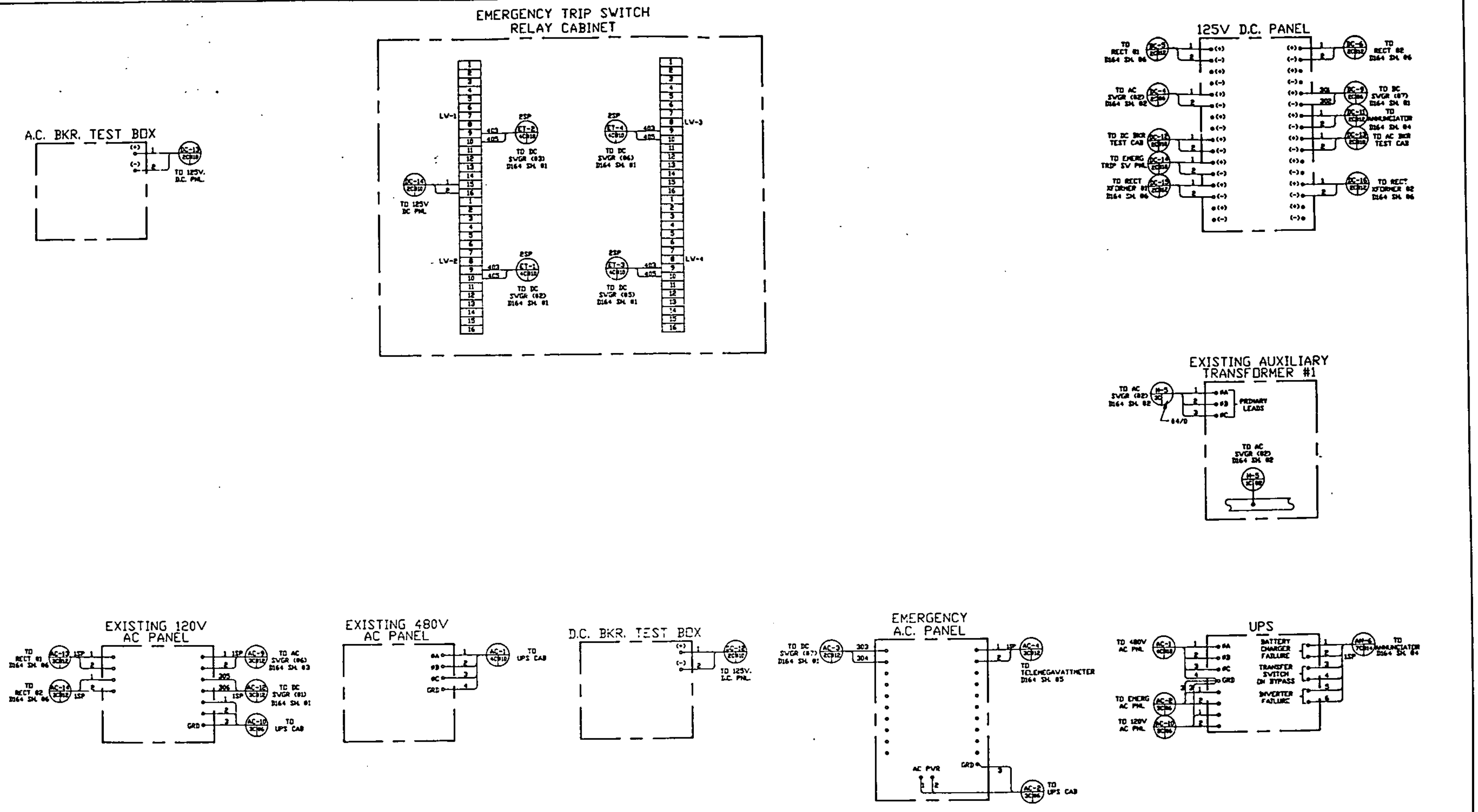
CUST. VMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE EQUIPMENT INTERCONNECTIONS FOR LANSDOWNE WAY SUBSTATION

DWG. NO. 4482-D164
SHEET 6 OF 7

REV 1

MAY 25 1990



REVISIONS			
NO	BY	DATE	
1	JAS	08/04/89	CUST. REV'S AC-13 AC-14, AC-12

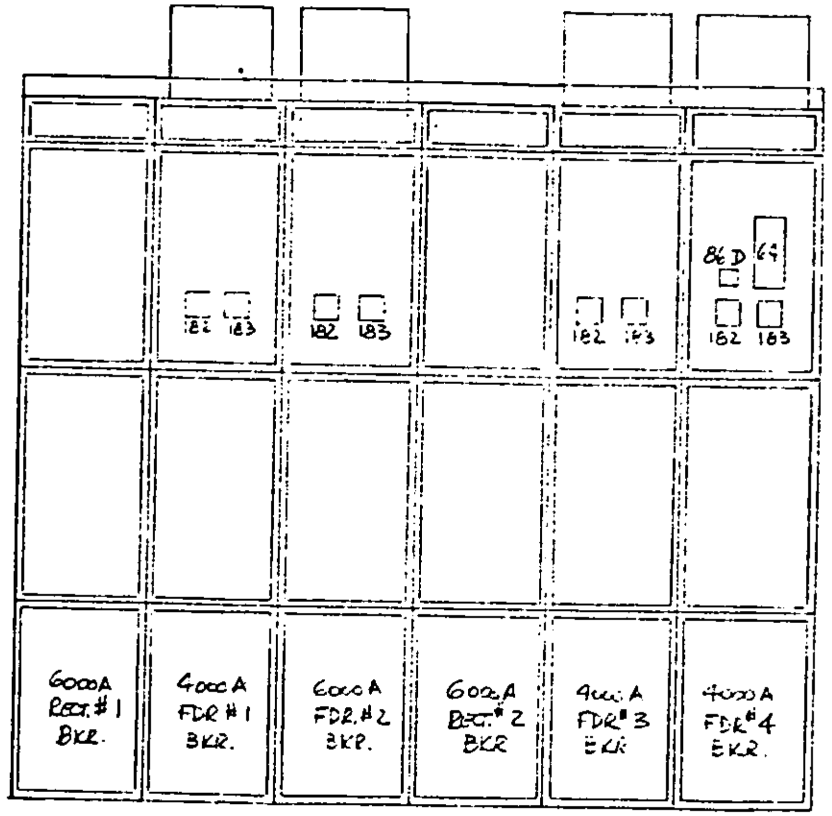
NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-15, SS9-E-16, SS9-E-17, SS9-E-18, SS9-E-19, SS9-E-20, SS9-E-21, SS9-E-22, SS9-E-23, SS9-E-72.

MICROFILMED 9-75-89

DRAWN BY R.R.R.	CONTROLLED POWER CORP.	TITLE EQUIPMENT INTERCONNECTIONS FOR LANSDOWNE WAY SUBSTATION	REV 1
DATE 3/17/69			
SCALE NTS	CUST. WMATA/SS-9		
CHK'D.	CONTRACT #1Z1049	DWG. NO. 4482-D164 SHEET 7 OF 7	
APP'D.	KINGSTON CONTRACTORS		

MAY 25 1990

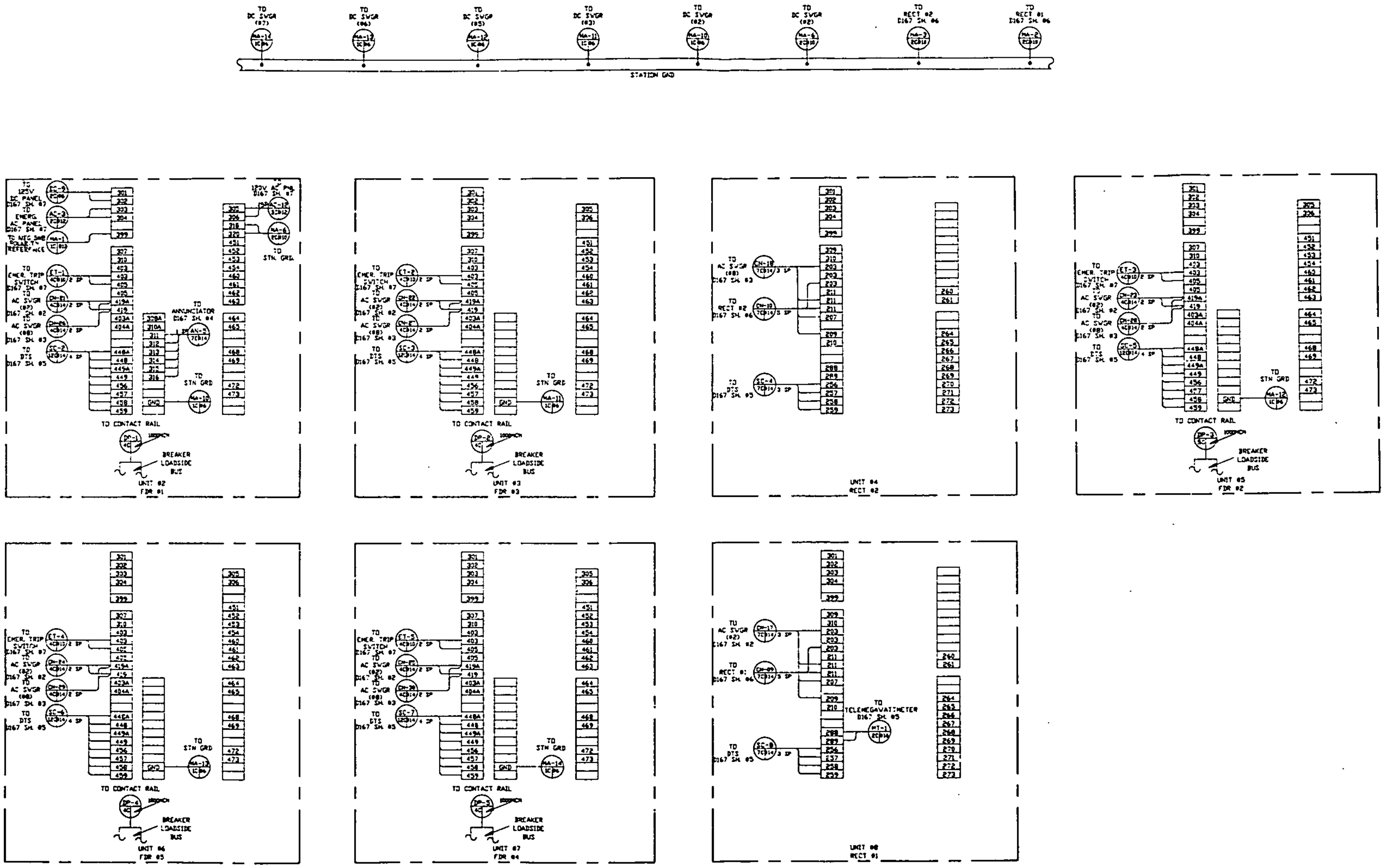


REAR VIEW

FOR ELEVATION & SECTION VIEW
SEE DWG № 4482-D 12

MICRO FILMED 9-30-88

DRAWN BY FSB	**CONTROLLED POWER CORP.** 211 WETMORE AVE., S.E. • P.O. BOX 133 MASSILLON, OHIO 44646	TITLE REAR VIEW
DATE 9/20/88		TRACTION POWER SUBSTATION LANDSDOWNE WAY D.C. SWITCHGEAR
SCALE	CUSTOMER WMATA/SS-9	
CHK'D		DWG. NO. 4482-C109
APP'D		REV.



DC SWITCHGEAR

REVISIONS

NO	BY	DATE	
1	[illegible]	[illegible]	[illegible]

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-58, SS9-E-59, SS9-E-60, SS9-E-61, SS9-E-62, SS9-E-63, SS9-E-64, SS9-E-65, SS9-E-66, SS9-E-75.
2. ALL CUSTOMER CONNECTION TO D.C. SWITCHGEAR MADE ON FRONT METERING COMPARTMENT TERMINAL BLOCKS. (WITH EXCEPTION OF POWER CABLE CONNECTIONS)
3. SPARE TERMINALS IN DC SWITCHGEAR ARE SHOWN AS BLANKS.

MICROFILMED

DRAWN BY R.R.R.
DATE 3/17/89
SCALE NTS
CHK'D.
APP'D.

CONTROLLED POWER CORP.

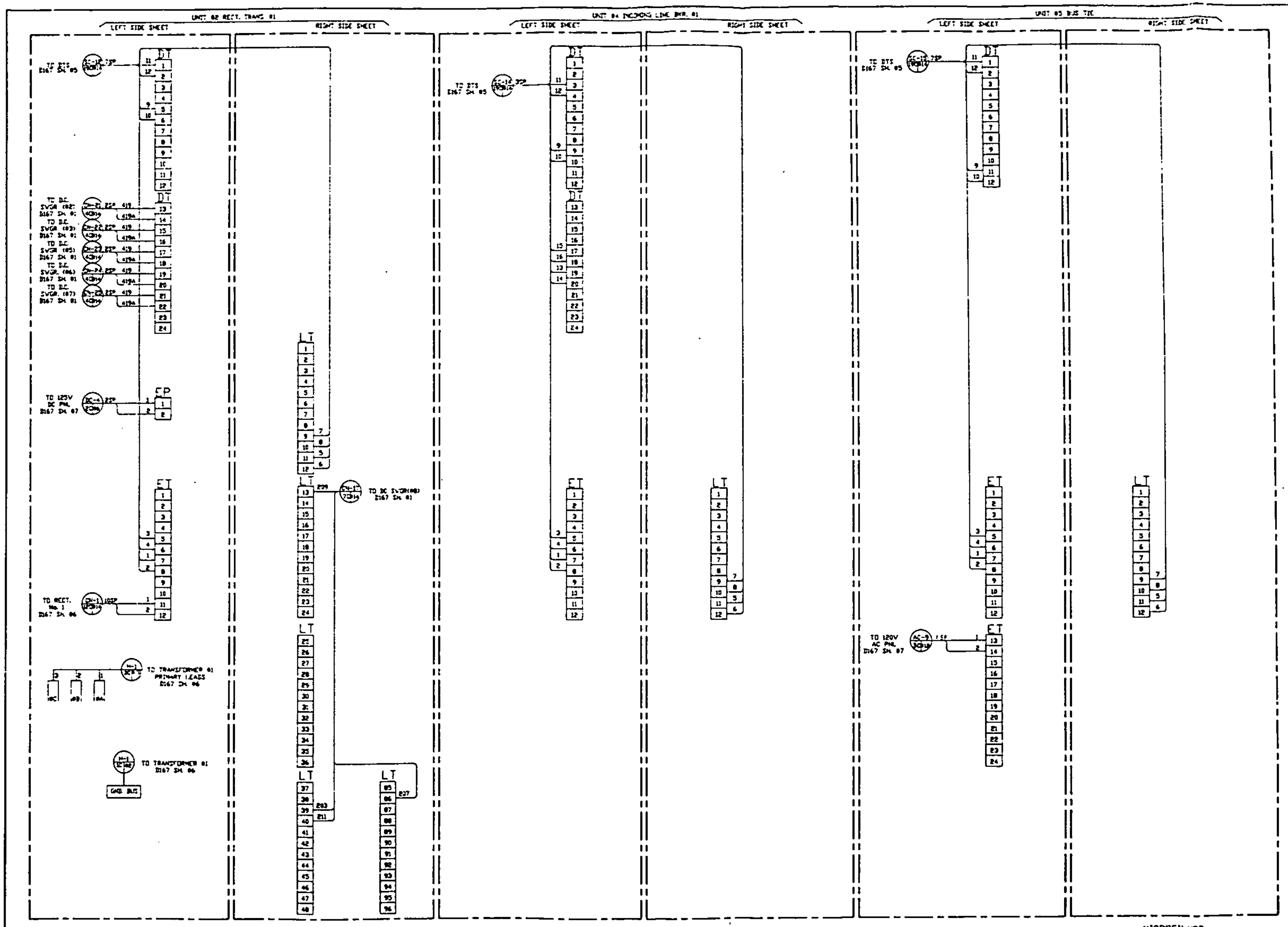
CUST. WMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE EQUIPMENT INTERCONNECTION FOR U-STREET SUBSTATION

DWG. NO. 4482-D167
SHEET 1 OF 7

REV 1

MAY 2 5 1990

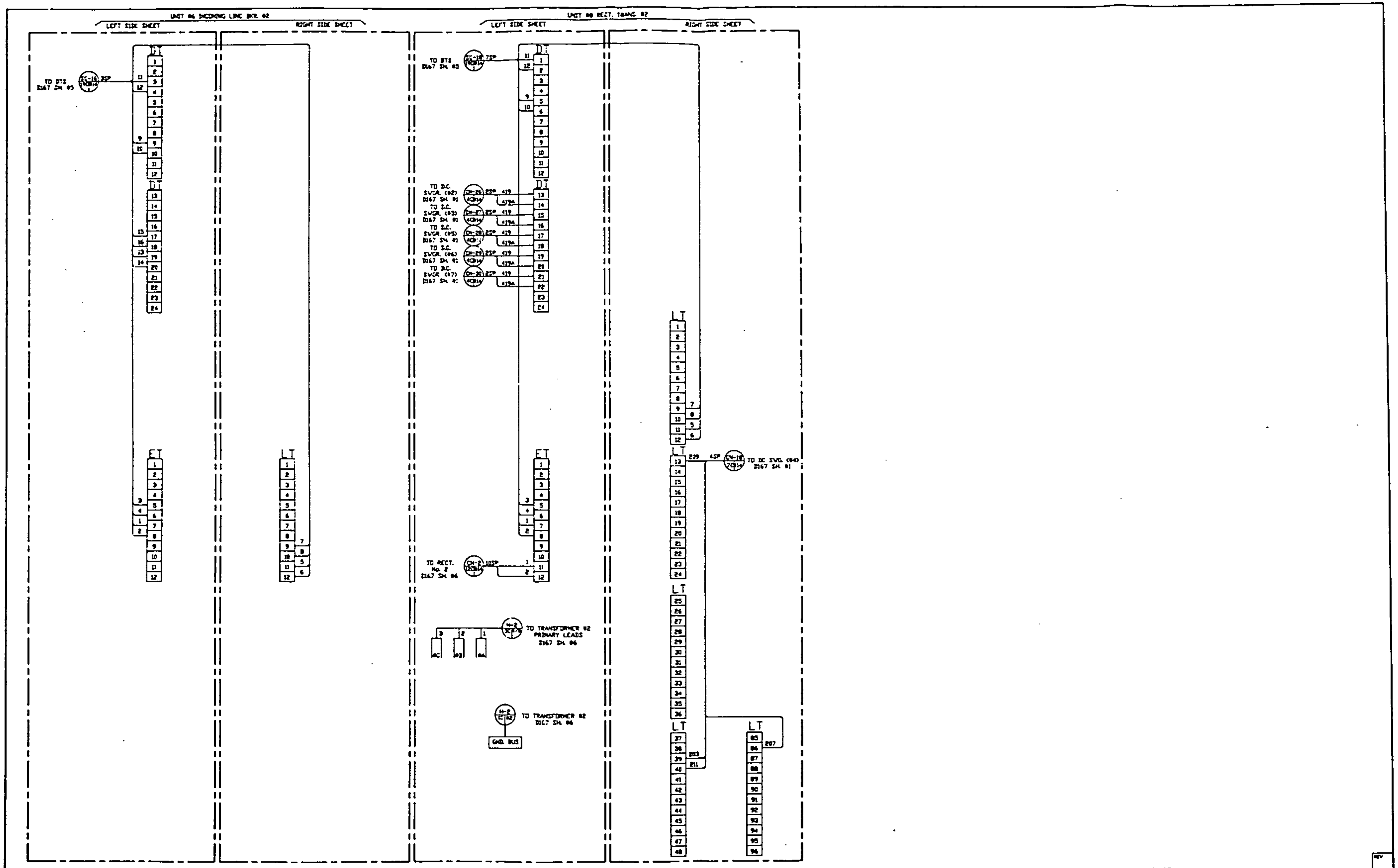


REVISIONS		
NO	BY	DATE
-		

NOTES:
1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-58, SS9-E-59, SS9-E-60, SS9-E-61, SS9-E-62, SS9-E-63, SS9-E-64, SS9-E-65, SS9-E-66, SS9-E-75.

MICROFILMED

DRAWN BY JHS	CONTROLLED POWER CORP.	TITLE EQUIPMENT INTERCONNECTION FOR U-STREET SUBSTATION	REV 1
DATE 3/17/89			
SCALE NTS	CUST. WMATA/SS-9		
CHK'D.	CONTRACT #1Z1049	DWG. NO. 4482-D167	
APP'D.	KINGSTON CONTRACTORS	SHEET 2 OF 7	



MICROFILMED 4/15/89

REVISIONS		
NO	BY	DATE

NOTES:
1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-58, SS9-E-59, SS9-E-60, SS9-E-61, SS9-E-62, SS9-E-63, SS9-E-64, SS9-E-65, SS9-E-66, SS9-E-75.

DRAWN BY MRS
DATE 3/17/89
SCALE NTS
CHK'D
APP'D

CONTROLLED POWER CORP.

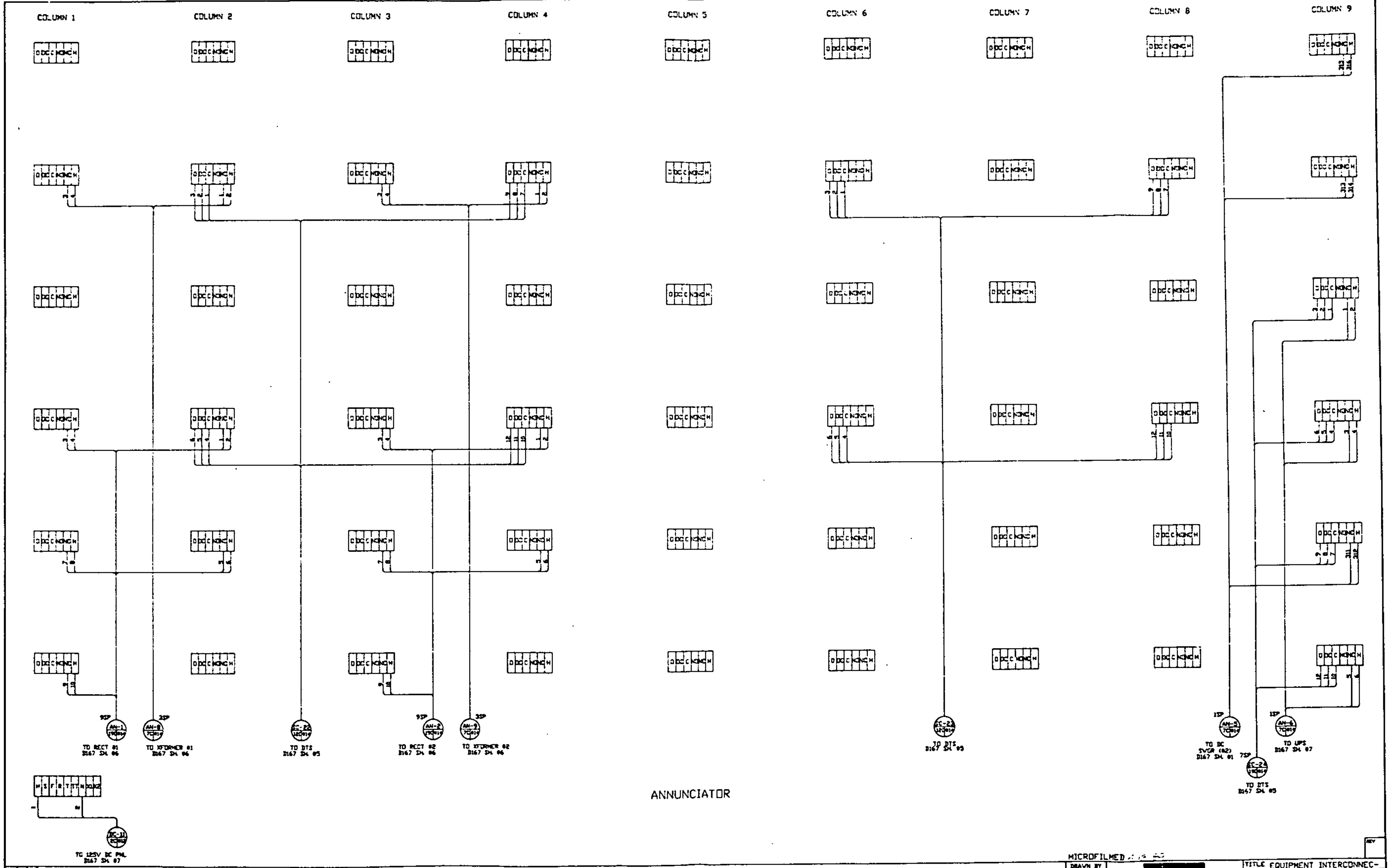
CUST. WMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE EQUIPMENT INTERCONNECTION FOR U-STREET SUBSTATION

DWG. NO. 4482-D167
SHEET 3 OF 7

REV

MAY 25 1990



REVISIONS
NO | BY | DATE

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-58, SS9-E-59, SS9-E-60, SS9-E-61, SS9-E-62, SS9-E-63, SS9-E-64, SS9-E-65, SS9-E-66, SS9-E-75.

MICROFILMED

DRAWN BY
R.R.R.
DATE
3/17/89
SCALE NTS
CHK'D.
APP'D.

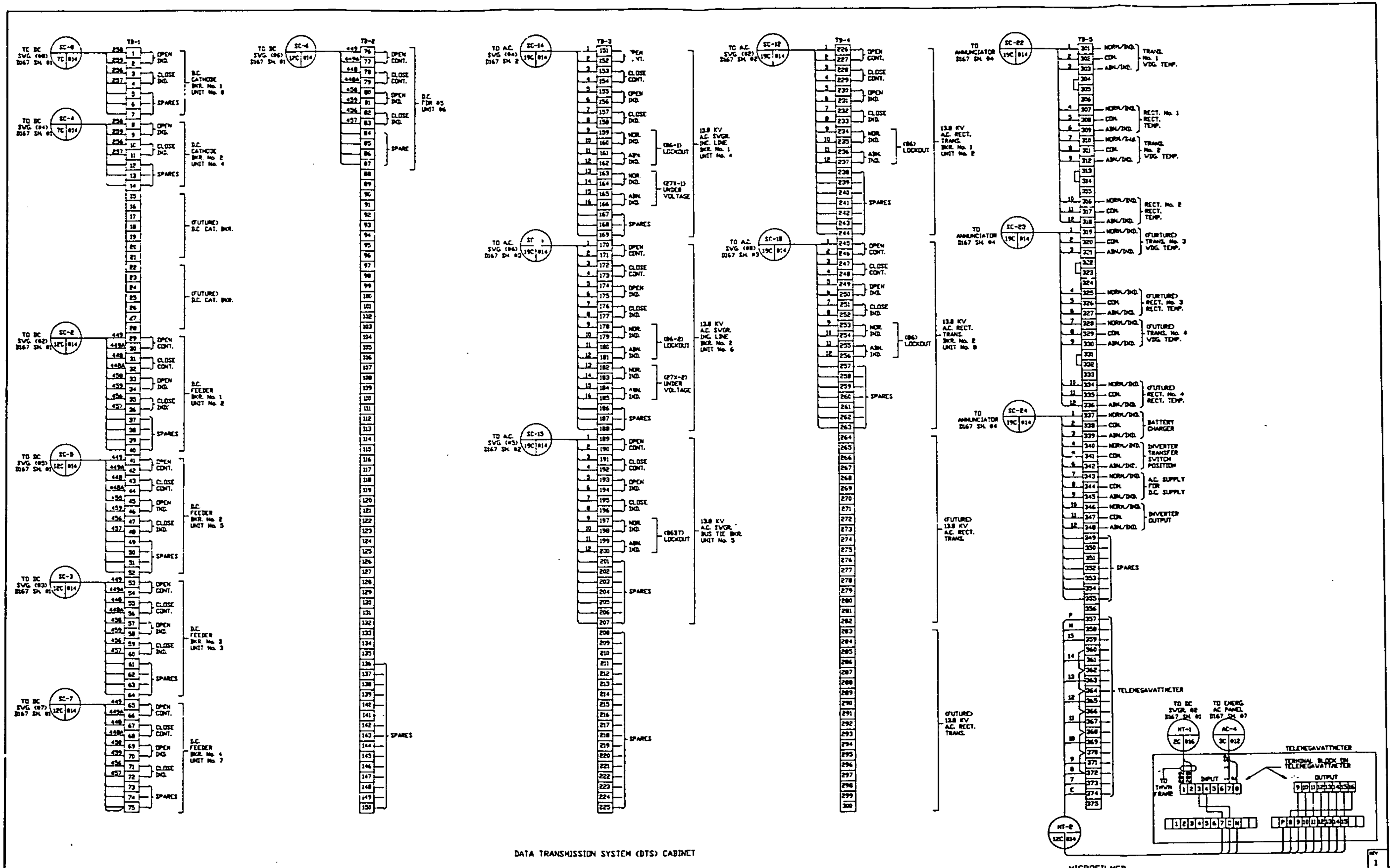
CONTROLLED POWER CORP.
CUST. WMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE EQUIPMENT INTERCONNECTION FOR U-STREET SUBSTATION

DWG. NO. 4482-D167
SHEET 4 OF 7

REV

MAY 25 1990



DATA TRANSMISSION SYSTEM (DTS) CABINET

MICROFILMED

REVISIONS		
NO	BY	DATE
1		9/22/89

REVISED WIRING AT TELEMEGAWATTMETER PER CUSTOMER REV.

NOTES:
1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-58, SS9-E-59, SS9-E-60, SS9-E-61, SS9-E-62, SS9-E-63, SS9-E-64, SS9-E-65, SS9-E-66, SS9-E-75.

DRAWN BY R.R.R.
DATE 3/17/89
SCALE NTS
CHK'D.
APP'D.

CONTROLLED POWER CORP.

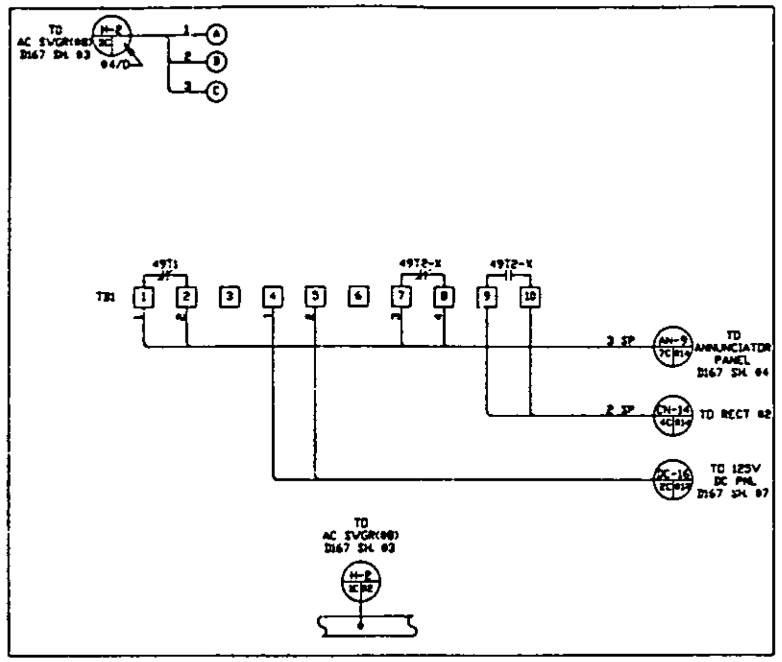
CUST. WMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE EQUIPMENT INTERCONNECTIONS FOR U-STREET SUBSTATION

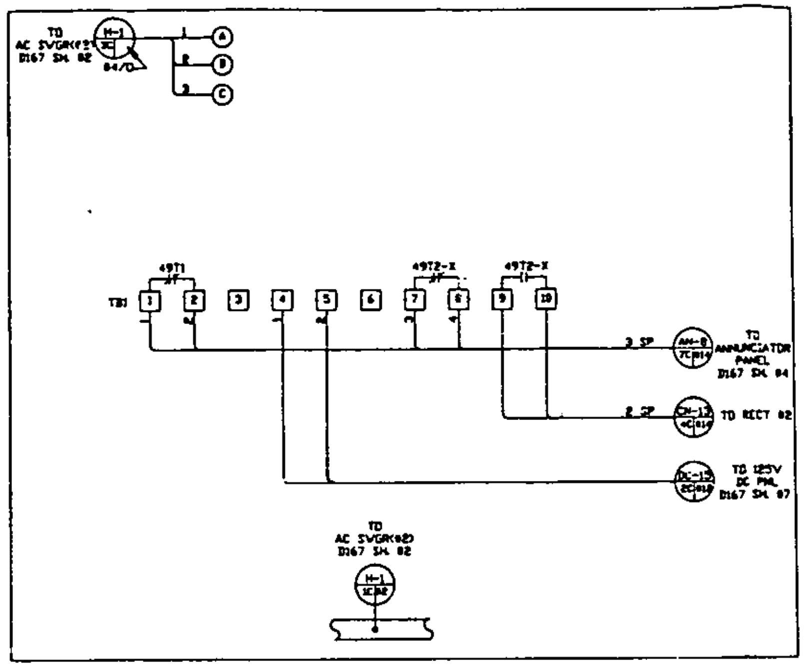
REV 1

DWG. NO. 4482-D167
SHEET 5 OF 7

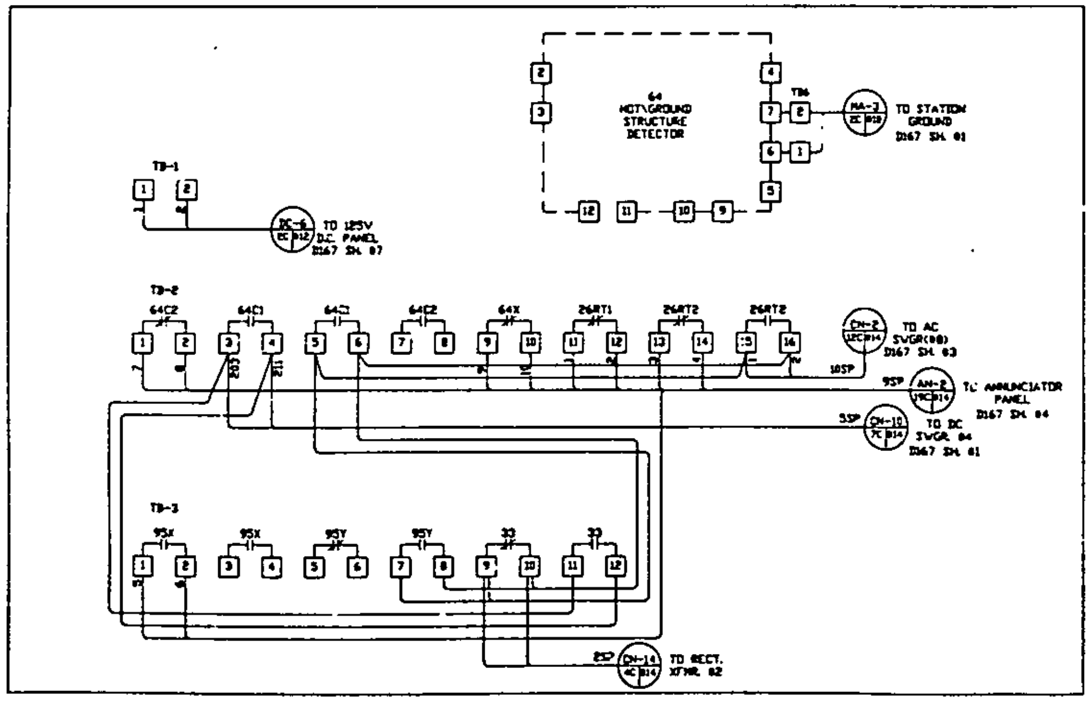
MAY 2 5 1990



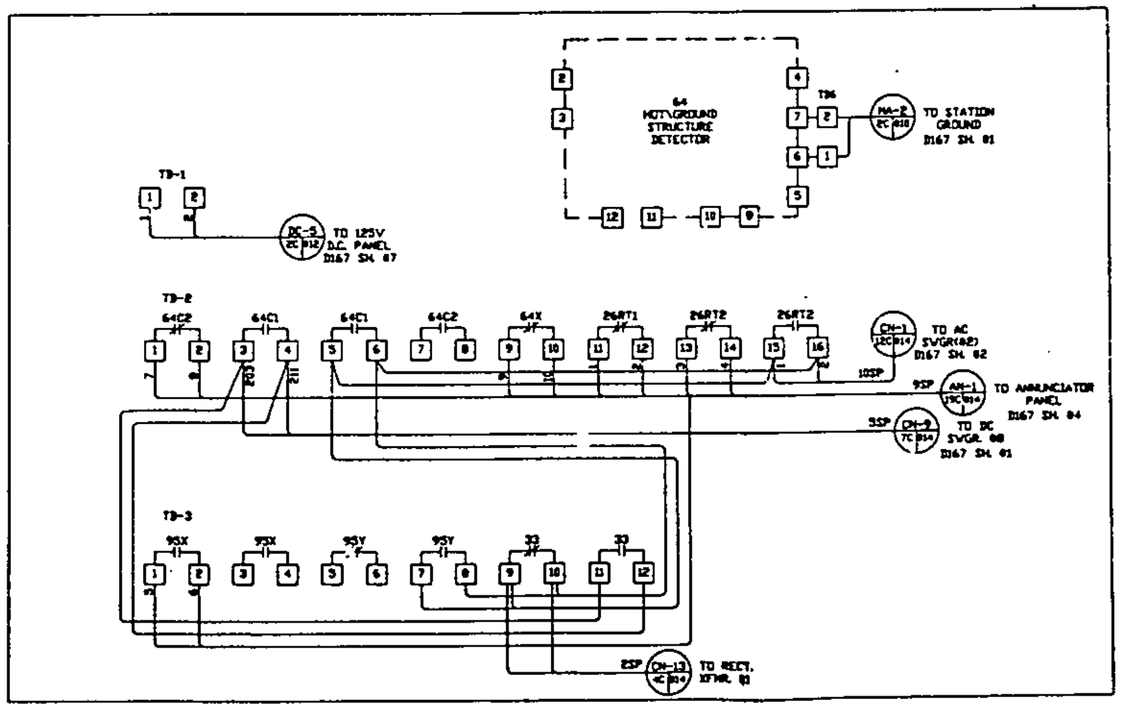
RECTIFIER TRANSFORMER #2



RECTIFIER TRANSFORMER #1



RECTIFIER #2



RECTIFIER #1

REVISIONS			
NO	BY	DATE	
1	RRR	9/22/89	REVD WIRING OF RECTIFIER & TRANSF. PER TEST REV.

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-58, SS9-E-59, SS9-E-60, SS9-E-61, SS9-E-62, SS9-E-63, SS9-E-64, SS9-E-65, SS9-E-66, SS9-E-73.

MICROFILMED

DRAWN BY R.R.R.

DATE 3/17/89

SCALE NTS

CHK'D.

APP'D.

CONTROLLED POWER CORP.

CUST. WMATA/SS-9

CONTRACT #1Z1049

KINGSTON CONTRACTORS

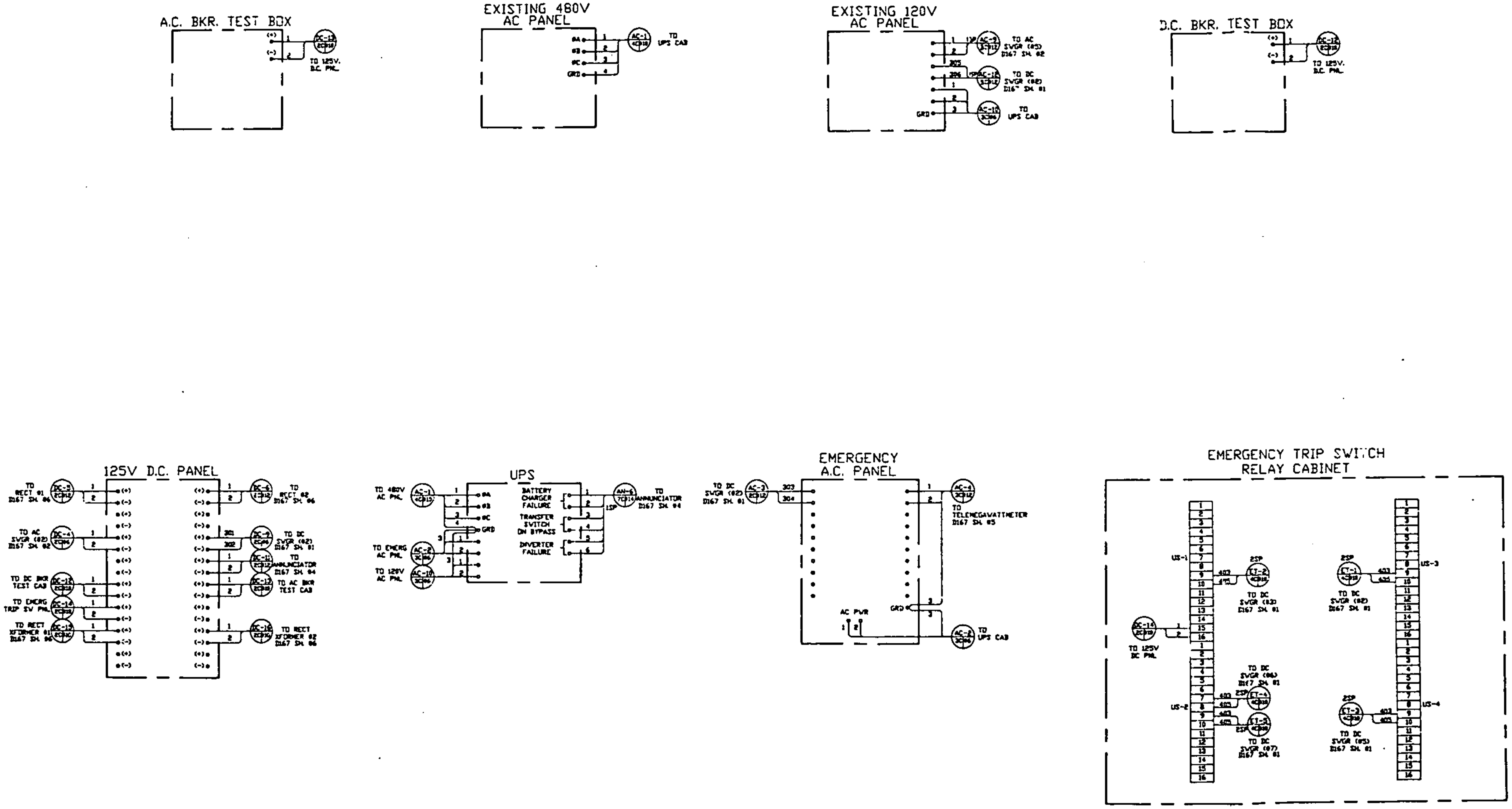
TITLE EQUIPMENT INTERCONNECTIONS FOR U-STREET SUBSTATION

REV 1

DWG. NO. 4482-D167

SHEET 6 OF 7

MAY 2 5 1990



NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-58, SS9-E-59, SS9-E-60, SS9-E-61, SS9-E-62, SS9-E-63, SS9-E-64, SS9-E-65, SS9-E-66, SS9-E-75.

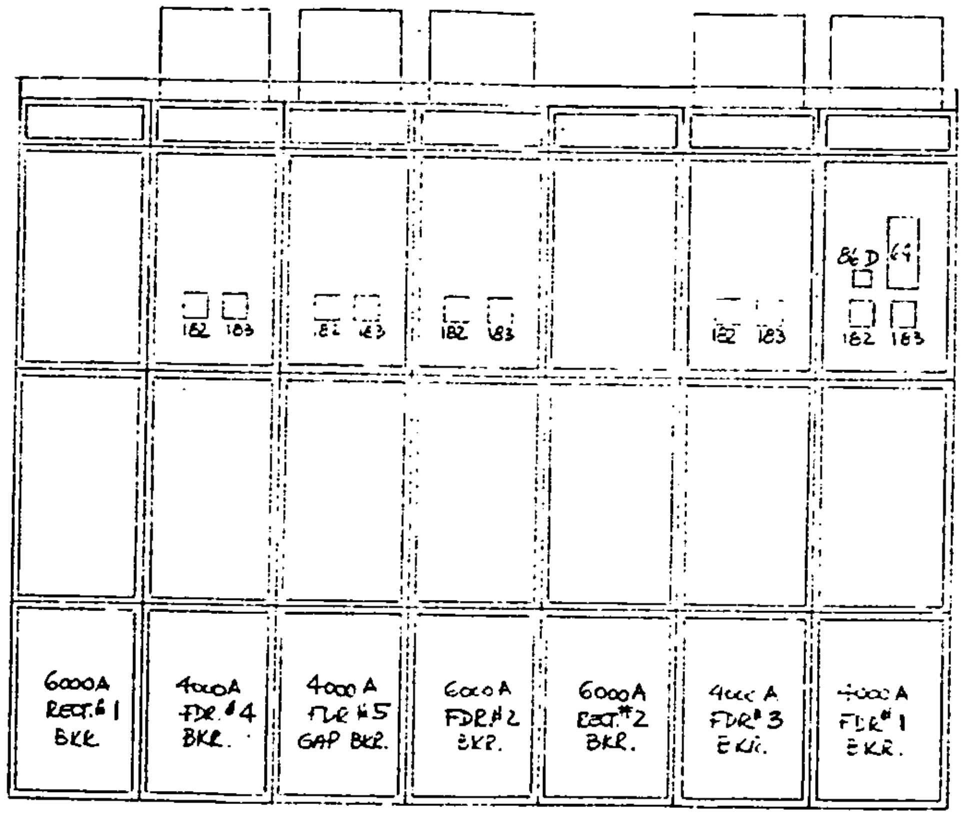
REVISIONS			
NO	BY	DATE	
1	[illegible]	[illegible]	[illegible]

MICROFILMED

DRAWN BY R.R.R.	CONTROLLED POWER CORP.	TITLE	EQUIPMENT INTERCONNECTIONS FOR U-STREET SUBSTATION
DATE 3/17/89			
SCALE NTS	CUST. VMATA/SS-9		
CHK'D.	CONTRACT #1Z1049	DWG. NO.	4482-D167
APP'D.	KINGSTON CONTRACTORS		SHEET 7 OF 7

REV 1

MAY 2 5 1990



REAR VIEW

FOR ELEVATION & SECTION VIEW
SEE DWG. № 4482-D13

MICRO FILMED 9-29-88

DRAWN BY FBB

DATE 9/20/88

CONTROLLED POWER CORP.
211 WETMORE AVE., S.E. • P. O. BOX 553
MASSILLON, OHIO 44646

SCALE

CUSTOMER WMATA / SS-9

CHK'D

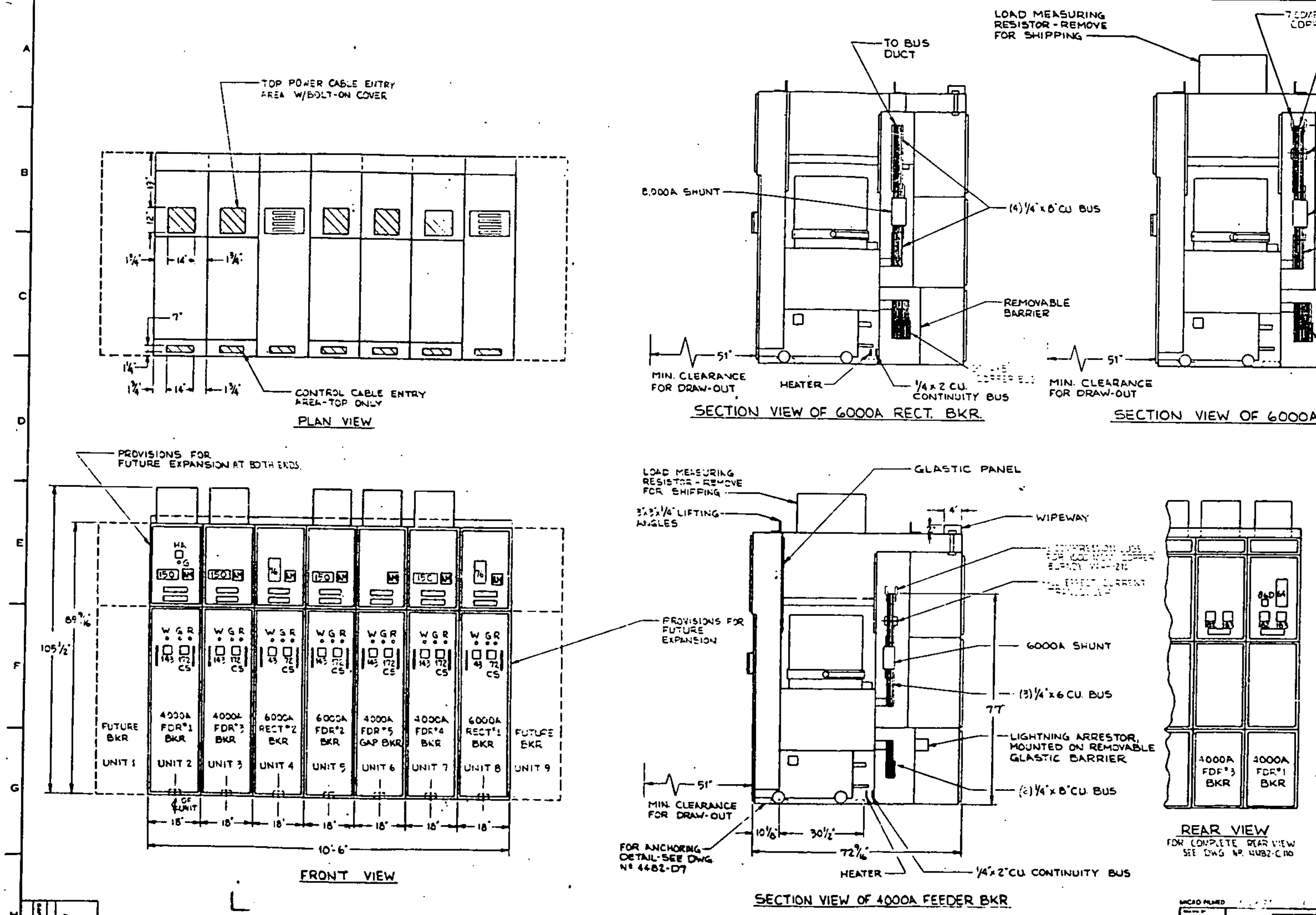
APP'D

TITLE REAR VIEW
TRACTION POWER SUBSTATION
U-STREET
D.C. SWITCHGEAR

DWG. NO. 4482-C110

REV.

MAY 2 5 1990



LEGEND

172CS	-BKR CONTROL SWITCH (FDR)
W	-WHITE LIGHT
G	-GREEN LIGHT
R	-RED LIGHT
AM	-AMMETER
64	-HIGH RESISTANCE GND. RELAY
86D	-LOCKOUT RELAY , SUBSTATION
143	-REMOTE/LOCAL SWITCH (FDR)
150	-RATE OF RISE RELAY
182	-CURRENT LOAD MEASURING RELAY
183	-VOLTAGE LOAD MEASURING RELAY
72CS	-BKR CONTROL SWITCH (RECT)
43	-REMOTE/LOCAL SWITCH (RECT)
HA	-HEATER AMMETER
76	-FORWARD CURRENT TRIP DEVICE

FINISH - LIGHT GRAY NO. 61 ANSI Z 55.1
MINIMUM CT 2 MILS THK.

WEIGHT -

SWITCHGEAR	- 8,400 lbs
BREAKERS (EA.)	- 650 lbs
TOTAL	-12,950 lbs

MICRO FILMED

PAP
5/21/85

CONTROLLED POWER CORP

WMATA/SS-9
CONTRACT # 121C49
KINGSTON CONTRACTORS

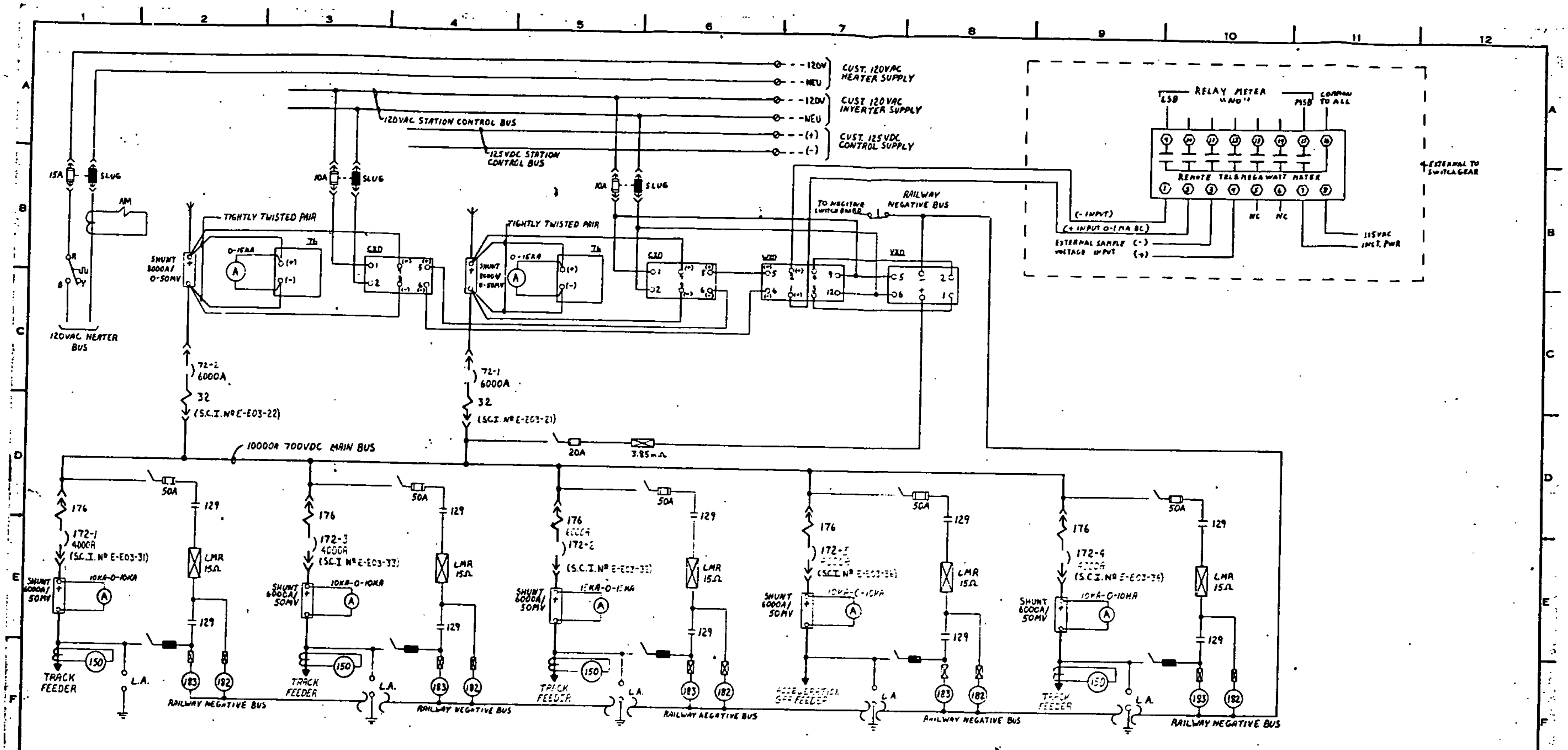
ELEVATION OF
SUBSTATION EQUIPMENT SS-9
TRACTION POWER SUBSTATION
U-STREET
-D.C. SWITCHGEAR

4482-D13

REV. 1

MAY 25 1990

D



NOTES:

FOR DEVICE LEGEND SEE 4482-A1
FOR DRAWING REFERENCE SHEET, SEE 4482-B2

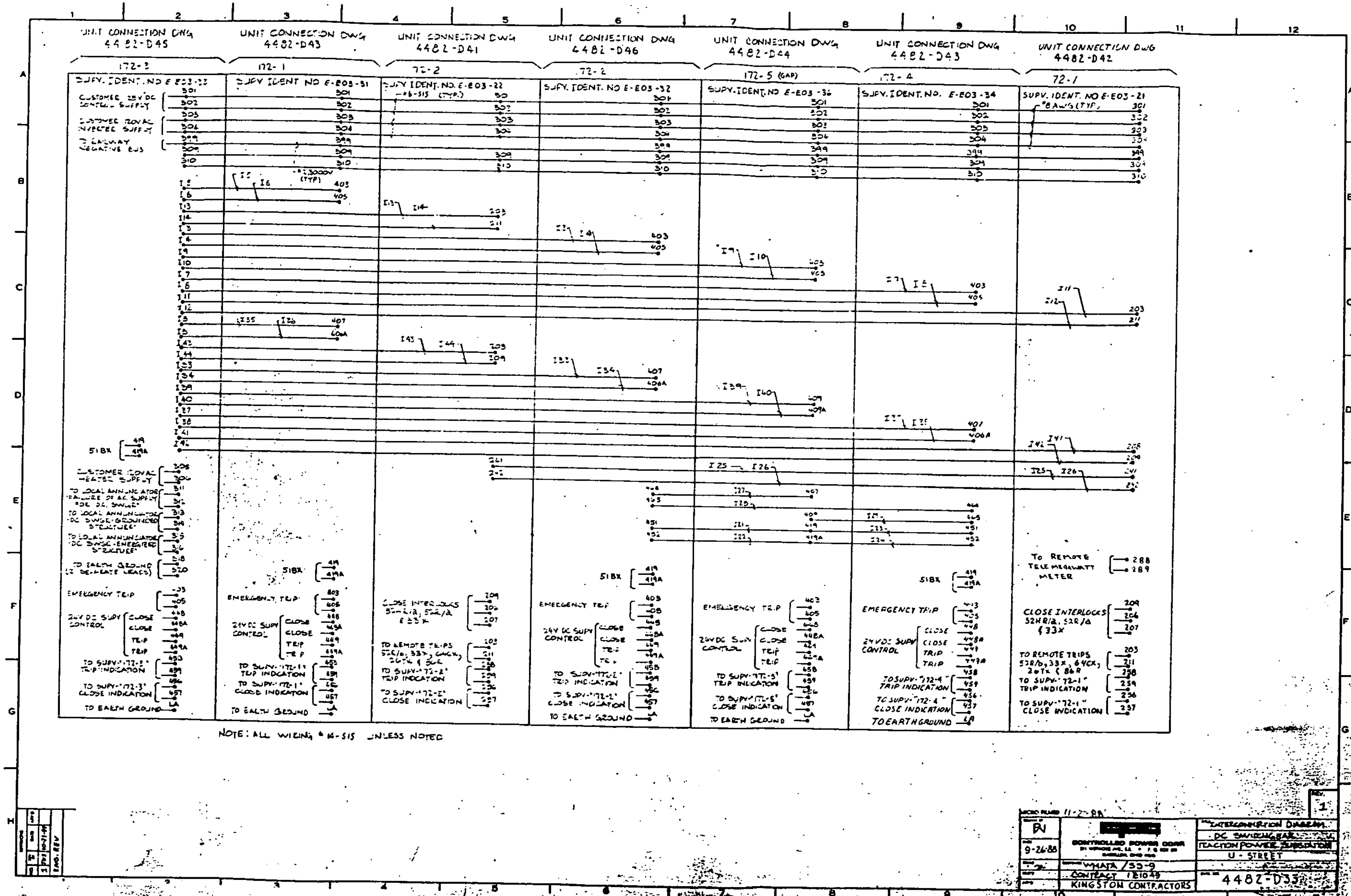
MICRO FILMED 13-4-88

JFK	CONTROLLED POWER CORP	POWER DIAGRAM DC SWITCHGEAR TRACTION POWER SUBSTATION "L" STREET
5-19-88	WMATA/SS-9 CONTRACT 1X1049 KINGSTON CONTRACTORS	4482-023

REV.

MAY 2 5 1990

D



MICRO FILMED 11-2-88

BN

9-26-88

CONTROLLED POWER CORP

WMATA /33-9

CONTRACT 1E1049

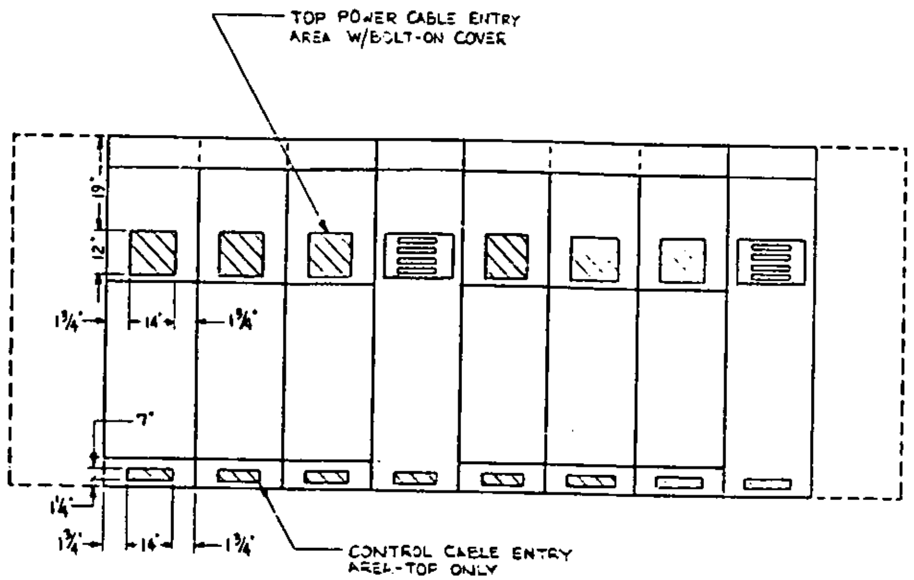
KINGSTON CONTRACTORS

INTERCONNECTION DIAGRAM
DC SWITCHGEAR
TRACTION POWER SUBSTATION
U - STREET

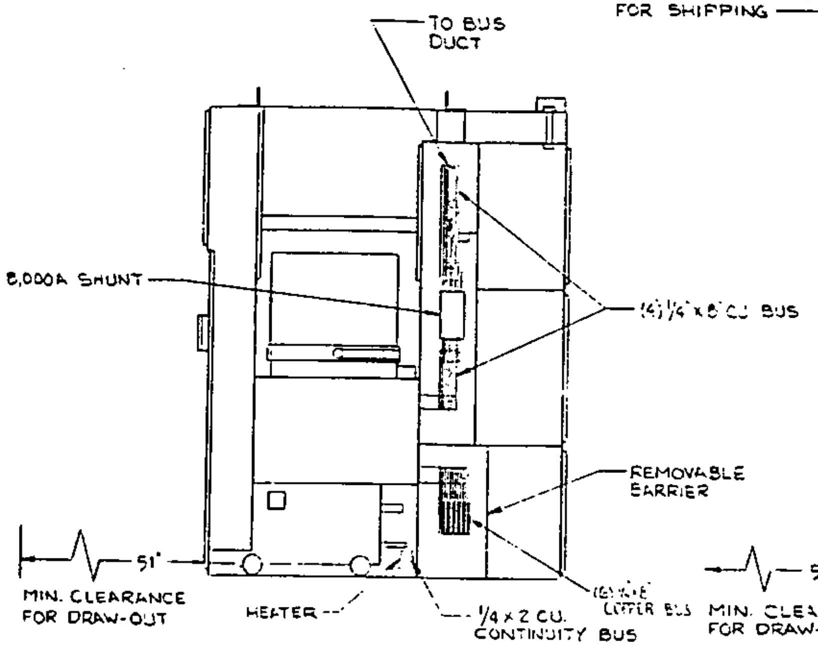
4482-D33

REV. 1

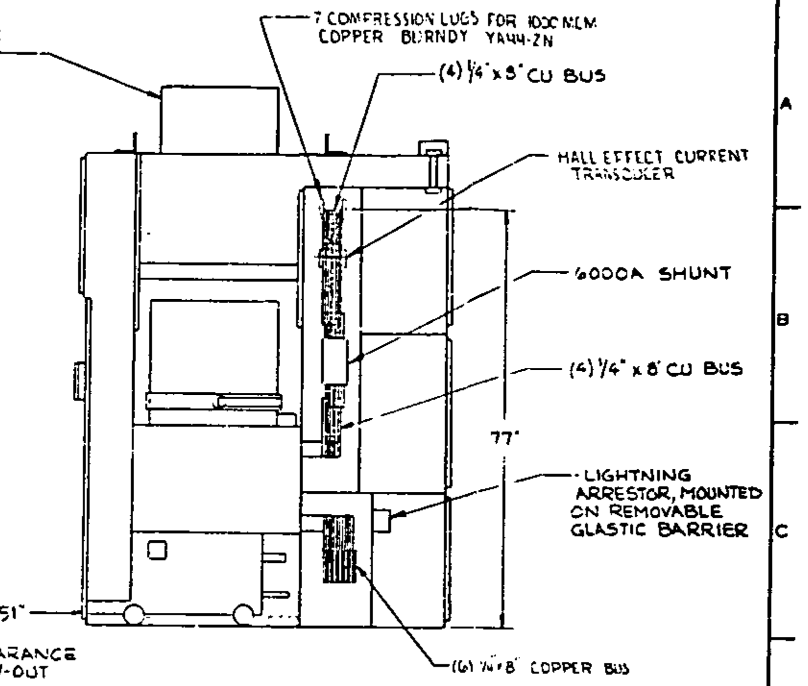
MAY 25 1990



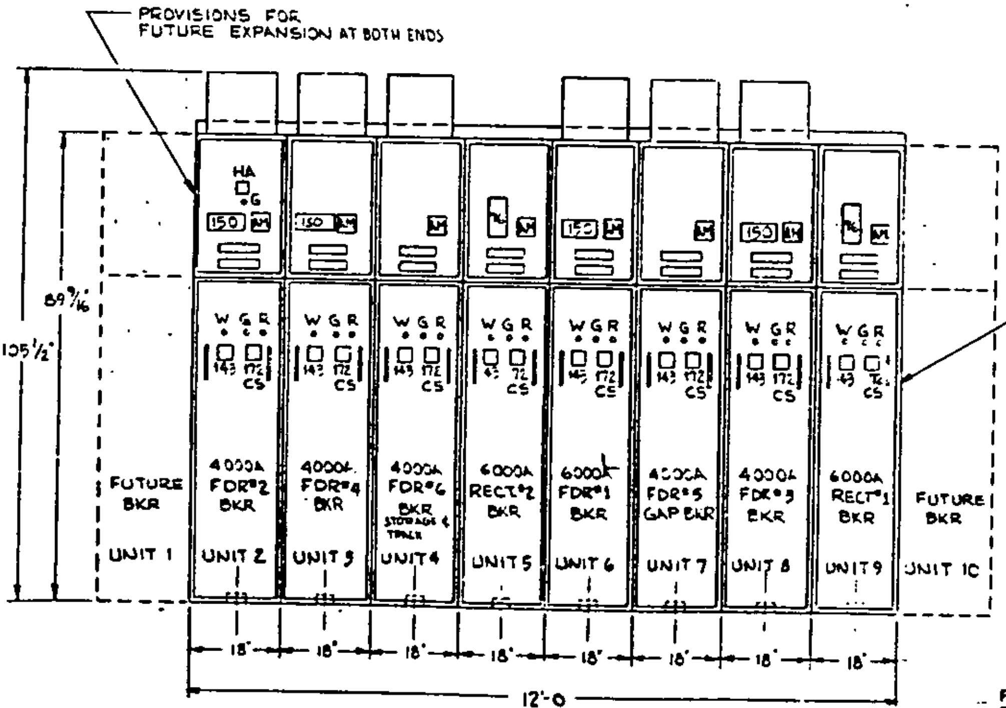
PLAN VIEW



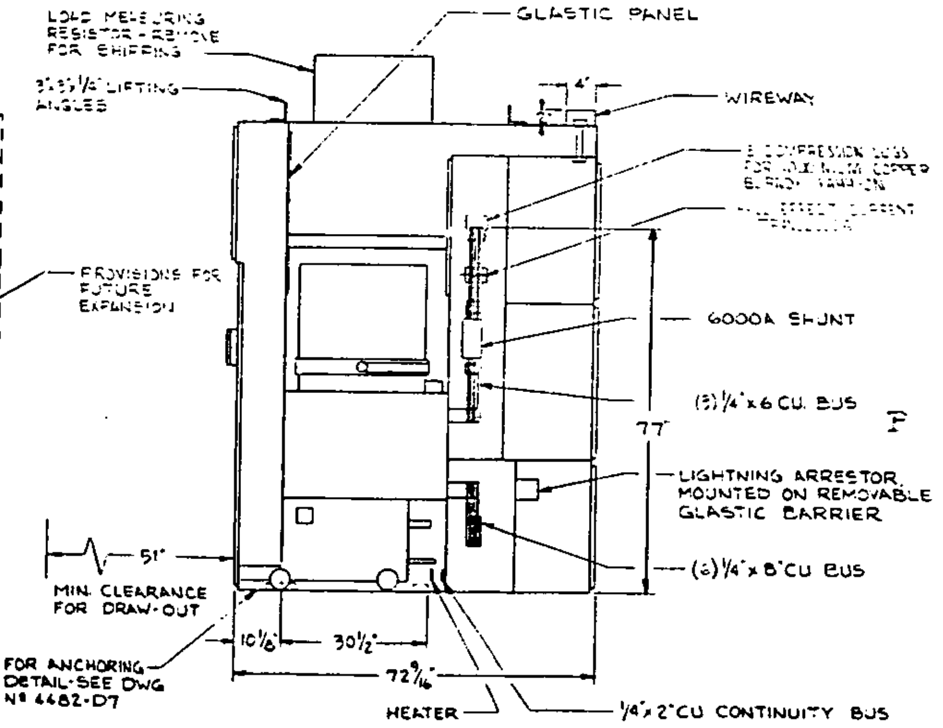
SECTION VIEW OF 6000A RECT. BKR.



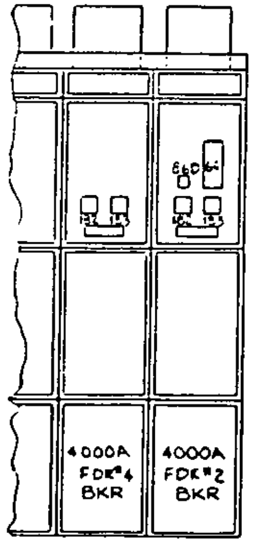
SECTION VIEW OF 6000A FDR. BKR.



FRONT VIEW



SECTION VIEW OF 4000A FEEDER BKR



REAR VIEW

FOR COMPLETE REAR VIEW SEE DWG. Nº 4482-C111

LEGEND

172CS -BKR CONTROL SWITCH (FDR)
W -WHITE LIGHT
G -GREEN LIGHT
R -RED LIGHT
AM -AMMETER
64 -HIGH RESISTANCE GND. RELAY
86D -LOCKOUT RELAY, SUBSTATION
143 -REMOTE/LOCAL SWITCH (FDR)
150 -RATE OF RISE RELAY
182 -CURRENT LOAD MEASURING RELAY
183 -VOLTAGE LOAD MEASURING RELAY
72CS -BKR CONTROL SWITCH (RECT.)
43 -REMOTE/LOCAL SWITCH (RECT.)
HA -HEATER AMMETER
76 -FORWARD CURRENT TRIP DEVICE

FINISH - LIGHT GREY Nº61 ANSI Z 55.1
MINIMUM OF 2 MILS THK.

WEIGHT -
SWITCHGEAR - 7,600 lbs
BREAKERS (EA.) - 650 lbs
TOTAL - 14,800 lbs

MICRO FILMED 9-29-86

PAB
5/21/85

CONTROLLED POWER CORP.

WMATA/SS-9
CONTRACT # 121049
KINGSTON CONTRACTORS

ELEVATION OF
SUBSTATION EQUIPMENT SS-9
TRACTION POWER SUBSTATION
MOUNT VERNON SQUARE
- D.C. SWITCHGEAR

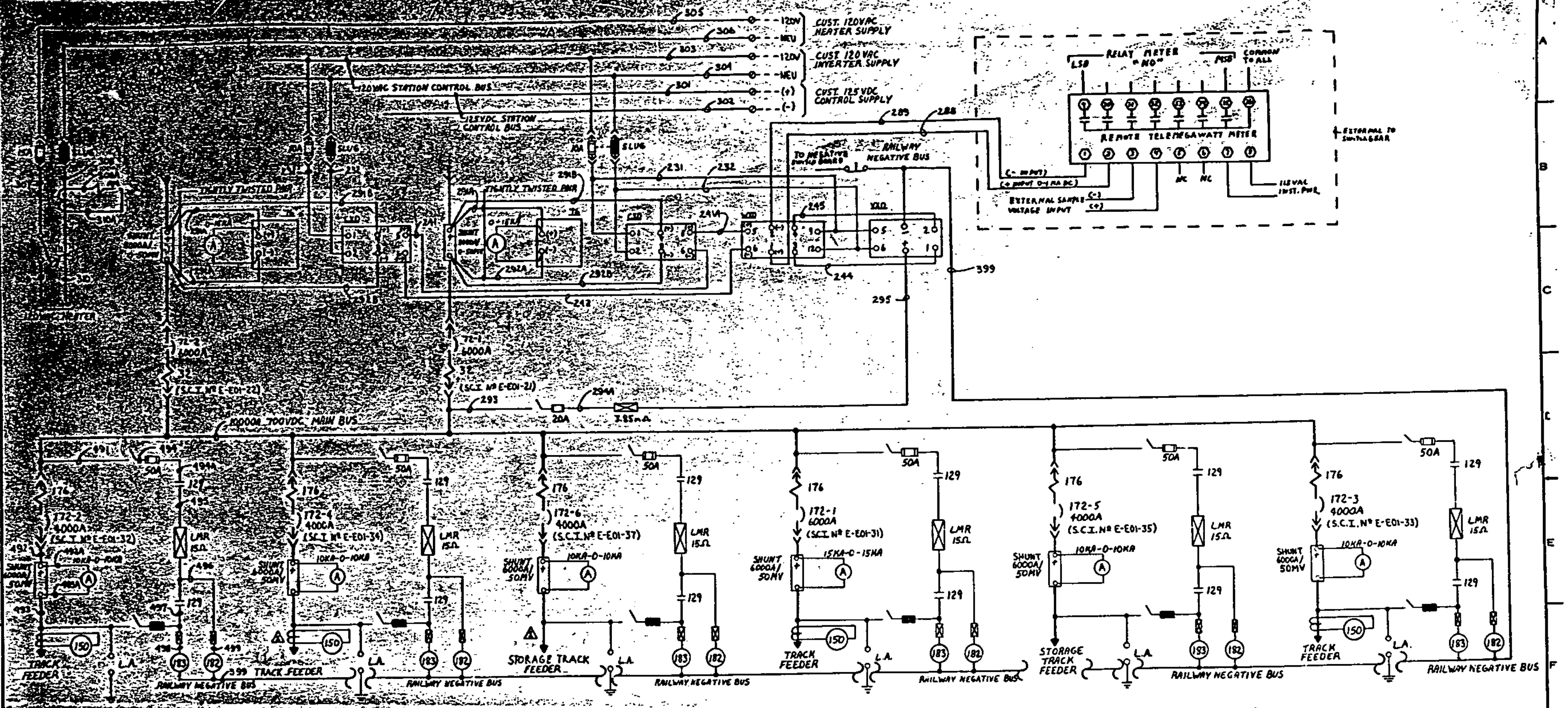
REV 1

4482-D14

SHEET 1 OF 1

MAY 25 1990

D



NOTES:

FOR DEVICE LEGEND SEE 4482-A1
FOR DRAWING REFERENCE SHEET, SEE 4482-B2

MICRO FILMED
IFK
5-19-88

CONTROLLED POWER CORP

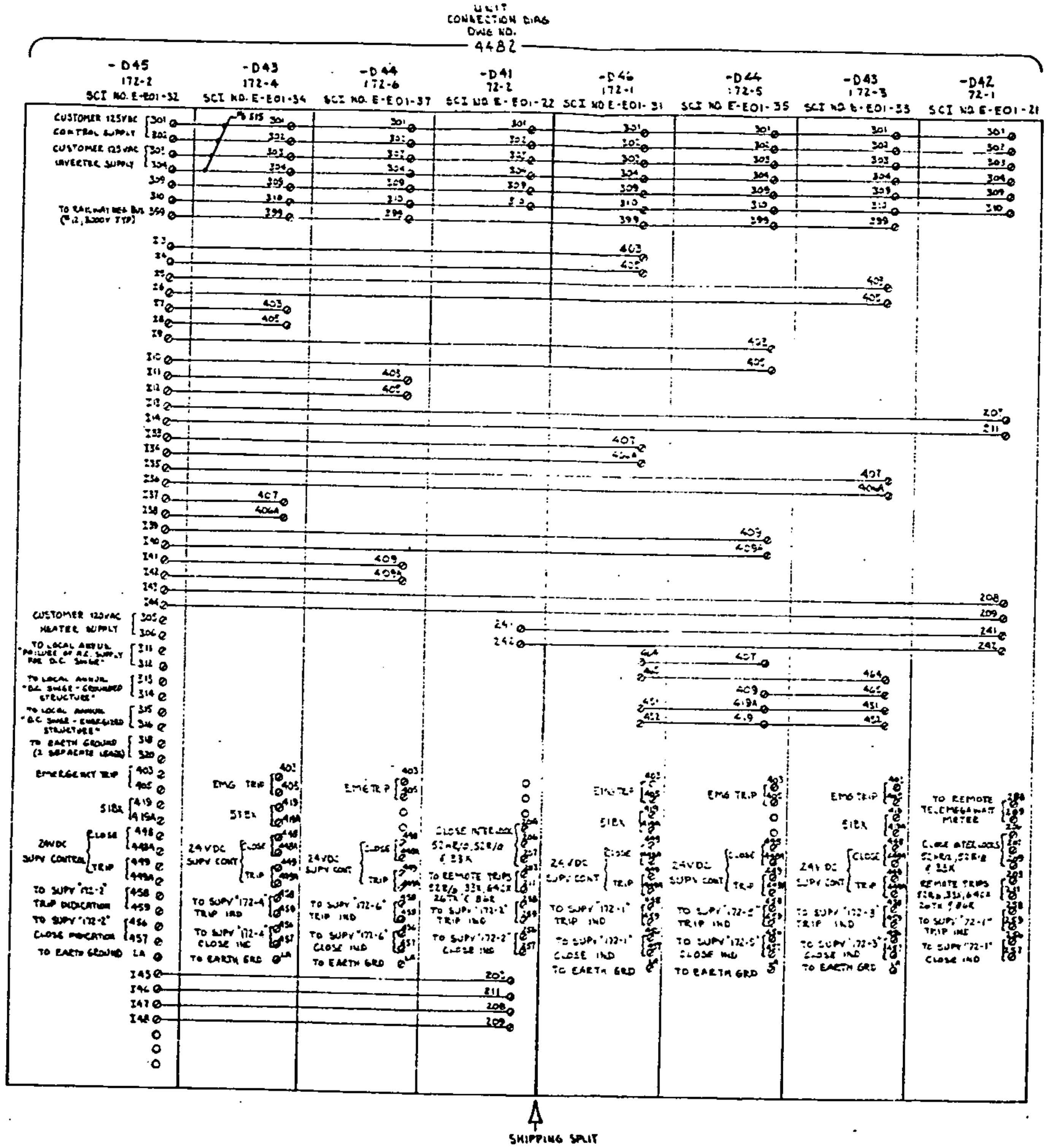
WMATA/SS-9
CONTRACT 121049
KINGSTON CONTRACTORS

POWER DIAGRAM
D.C. SWITCHGEAR
TRACTION POWER SUBSTATION
MOUNT VERNON SQUARE

REV.

4482-D24

MAY 2 5 1990



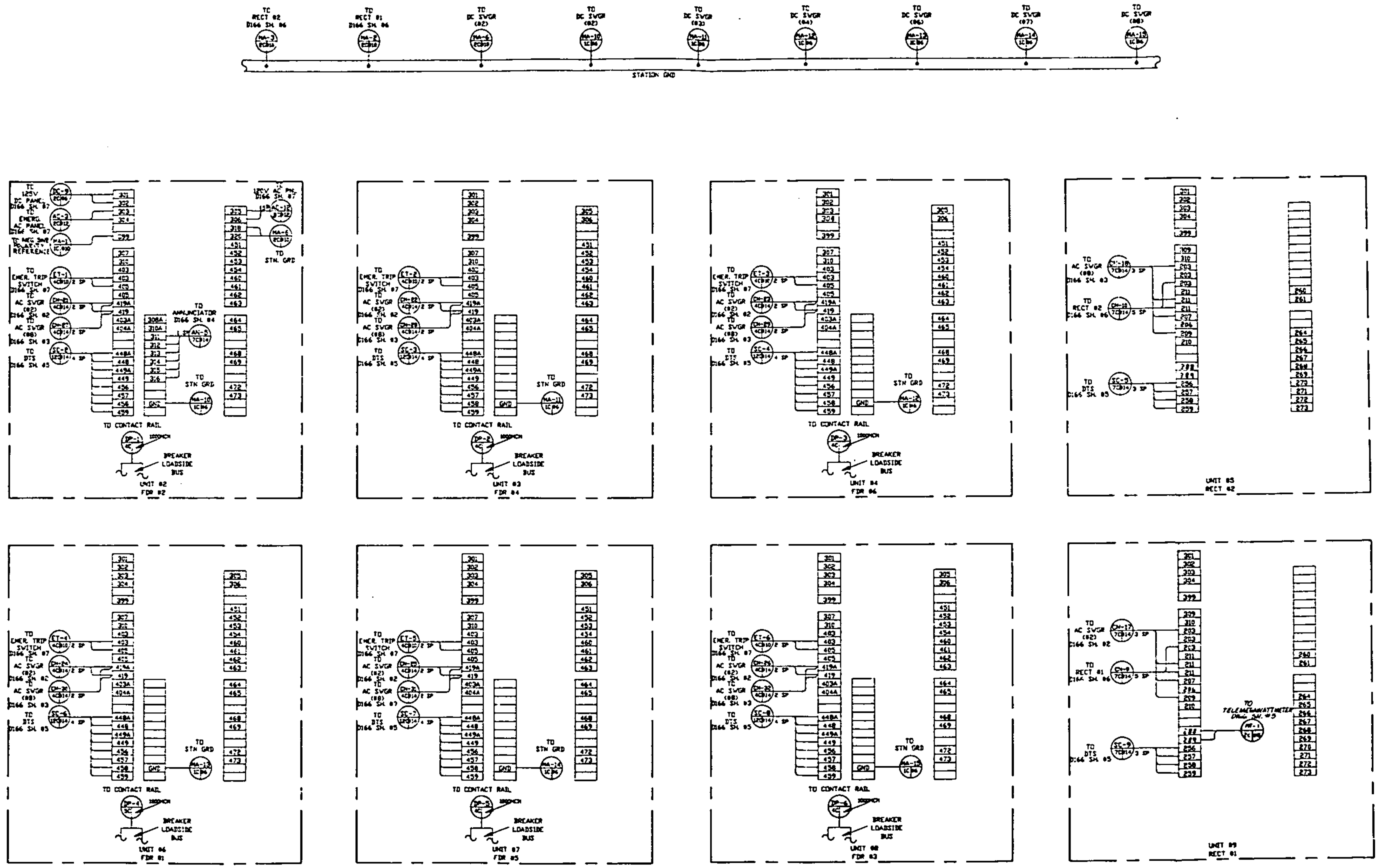
NOTES:
ALL WIRE NO #14 SIS UNLESS NOTED OTHERWISE.

MAY 25 1990

MICRO FILMED 11-2-88

BN	CONTROLLED POWER CORP	INTERCONNECTION DIAGRAM - SWITCHGEAR TRACTION POWER SUBSTATION - MT VERNON SQUARE
9-23-88	WMATA / 569	
	CONTRACT #1C1049	
	KINGSTON CONTRACTORS	4482-D34

1



DC SWITCHGEAR

REVISIONS			
NO	BY	DATE	
1	MRS	9-22-89	[illegible]

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-45, SS9-E-46, SS9-E-47, SS9-E-48, SS9-E-49, SS9-E-50, SS9-E-51, SS9-E-52, SS9-E-53, SS9-E-74.
2. ALL CUSTOMER CONNECTION TO D.C. SWITCHGEAR MADE ON FRONT METERING COMPARTMENT TERMINAL BLOCKS. (WITH EXCEPTION OF POWER CABLE CONNECTIONS)
3. SPARE TERMINALS IN DC SWITCHGEAR ARE SHOWN AS BLANKS.

MICROFILMED

DRAWN BY R.R.R.
DATE 3/20/89
SCALE NTS
CHK'D.
APP'D.

CONTROLLED POWER CORP.

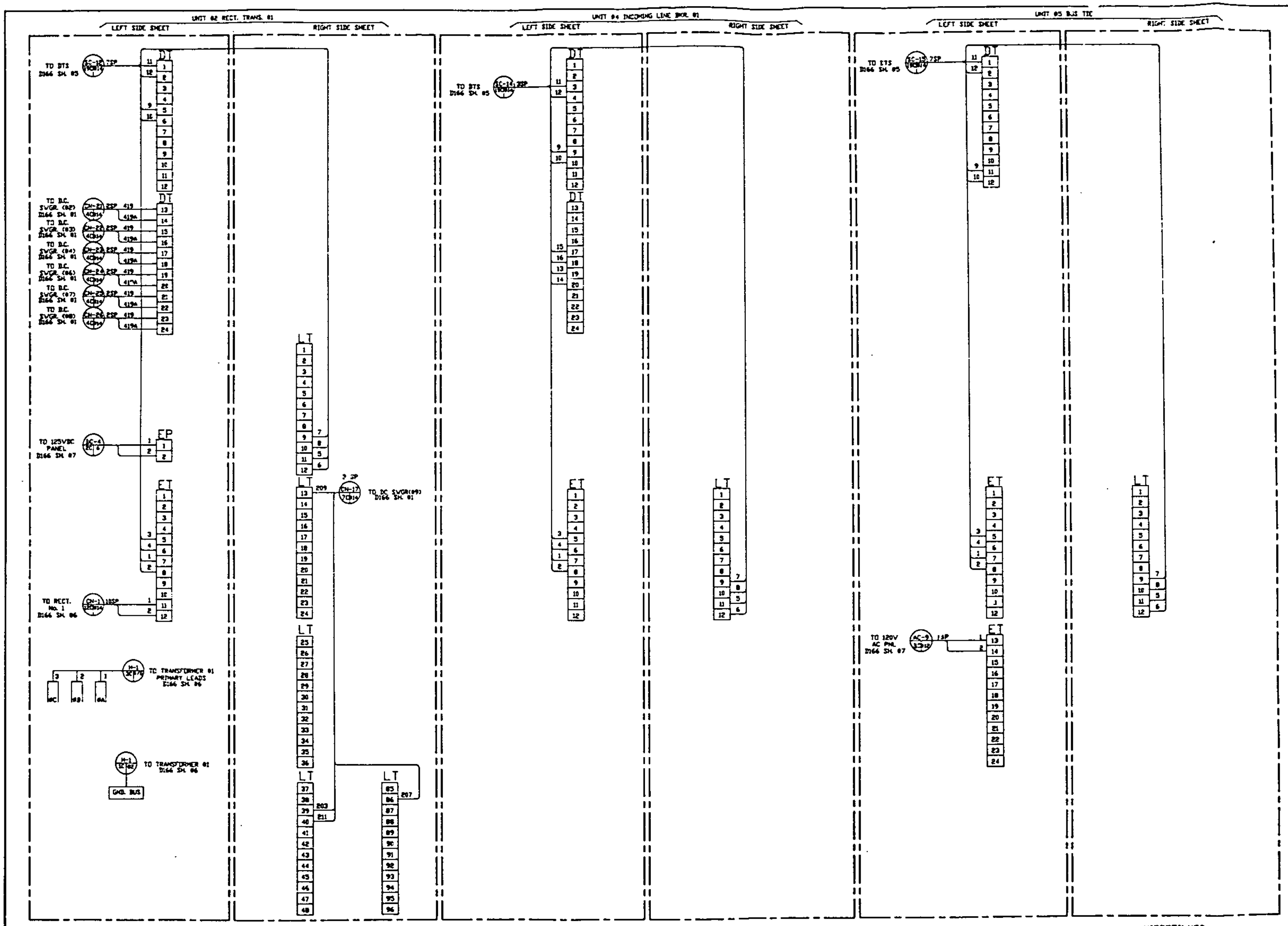
CUST. WMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE EQUIPMENT INTERCONNECTION FOR MOUNT VERNON SQ. SUBSATATION

DWG. NO. 4482-D166
SHEET 1 OF 7

REV 1

MAY 25 1990



NOTES:
1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-45, SS9-E-46, SS9-E-47, SS9-E-48, SS9-E-49, SS9-E-50, SS9-E-51, SS9-E-52, SS9-E-53, SS9-E-74.

REVISIONS			
NO	BY	DATE	
1	HRS	9/22/89	CHGD CABLE NO.'S TO REF. CUST. REV.

MICROFILMED

MAY 25 1990

REV 1

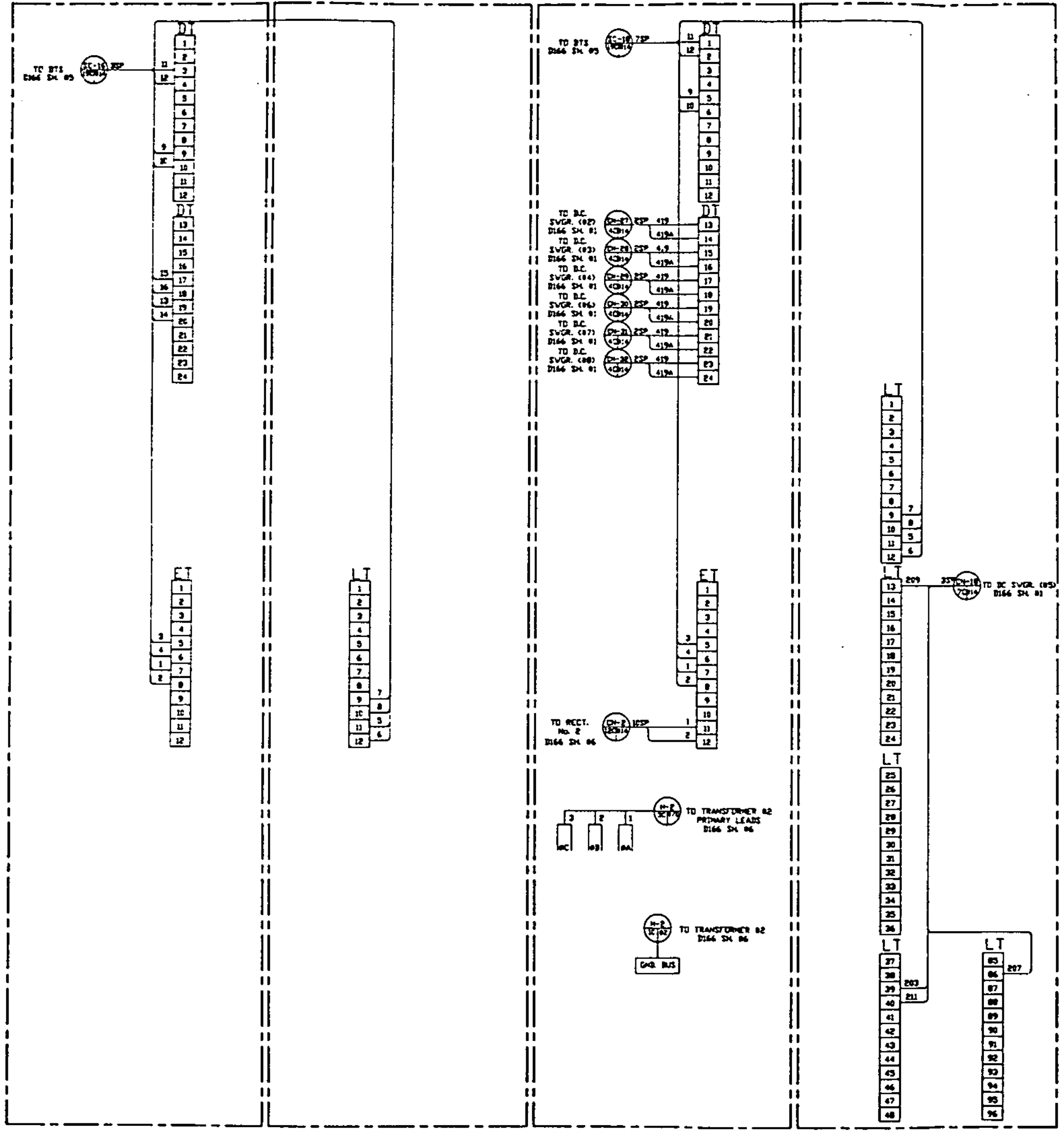
DRAWN BY HRS
DATE 3/17/89
SCALE NTS
CHK'D.
APP'D.

CONTROLLED POWER CORP.

CUST. WMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE EQUIPMENT INTERCONNECTION FOR MOUNT VERNON SQ. SUBSTATION

DWG. NO. 4482-D166
SHEET 2 OF 7



REVISIONS		
NO	BY	DATE

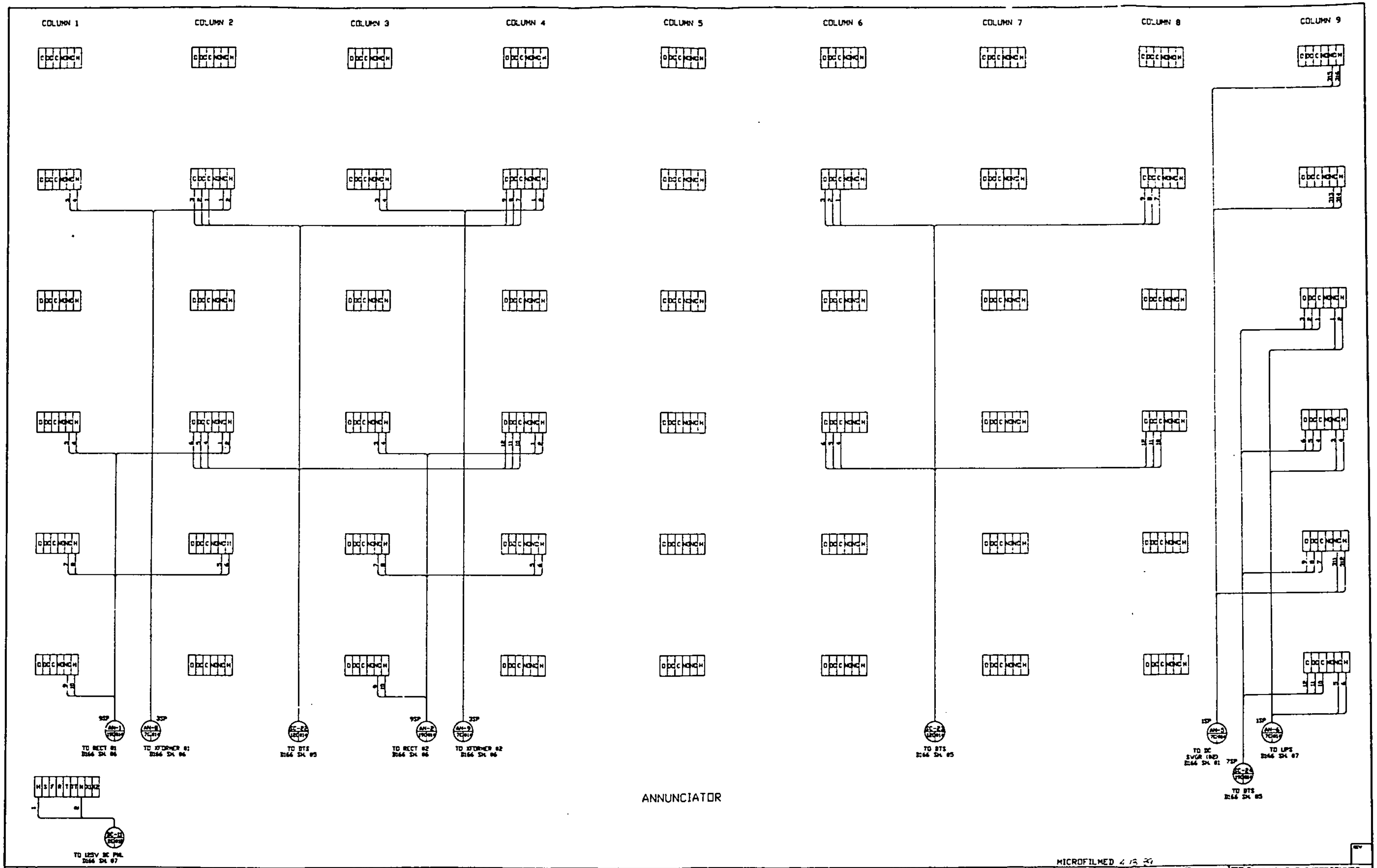
NOTES:
1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-45, SS9-E-46, SS9-E-47, SS9-E-48, SS9-E-49, SS9-E-50, SS9-E-51, SS9-E-52, SS9-E-53, SS9-E-74.

MICROFILMED 4-15-29

DRAWN BY MRS	CONTROLLED POWER CORP.	TITLE	EQUIPMENT INTERCONNEC- TION FOR MOUNT VERNON SQ. SUBSTATION
DATE 3/17/89			
SCALE NTS	CUST. WMATA/SS-9		
CHK'D.	CONTRACT #1Z1049	DWG. NO.	4482-D166 SHEET 3 OF 7
APP'D.	KINGSTON CONTRACTORS		

REV

MAY 25 1990



REVISIONS
NO. | BY | DATE

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-45, SS9-E-46, SS9-E-47, SS9-E-48, SS9-E-49, SS9-E-50, SS9-E-51, SS9-E-52, SS9-E-53, SS9-E-74.

MICROFILMED 4/6/90

DRAWN BY R.R.R.
DATE 3/17/89
SCALE NTS
CHK'D.
APP'D.

[redacted]
CONTROLLED POWER CORP.

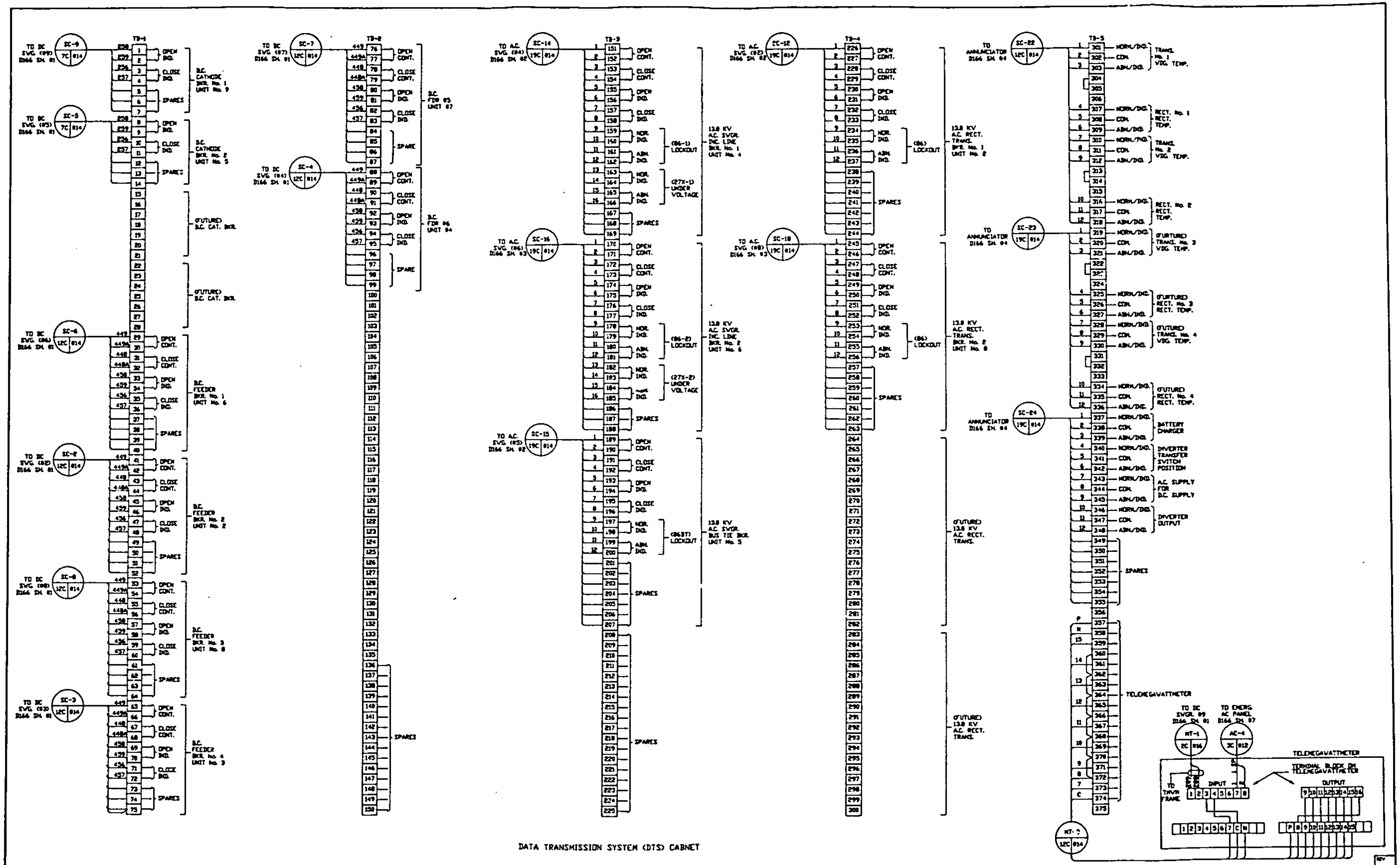
CUST. VHATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE EQUIPMENT INTERCONNECTION FOR MOUNT VERNON SQ. SUBSTATION

DWG. NO. 4482-D166
SHEET 4 OF 7

REV

MAY 25 1990



DATA TRANSMISSION SYSTEM (DTS) CABNET

REVISIONS		
NO	BY	DATE
1	[illegible]	9/22/89

REV'D WIRING AT TELEMEGAVATTMETER PER CUSTOMER REV.

NOTES:
1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-45, SS9-E-46, SS9-E-47, SS9-E-48, SS9-E-49, SS9-E-50, SS9-E-51, SS9-E-52, SS9-E-53, SS9-E-74.

MICROFILMED

DRAWN BY R.R.R.
DATE 3/17/89
SCALE NTS
CHK'D.
APP'D. BCJ

CONTROLLED POWER CORP.

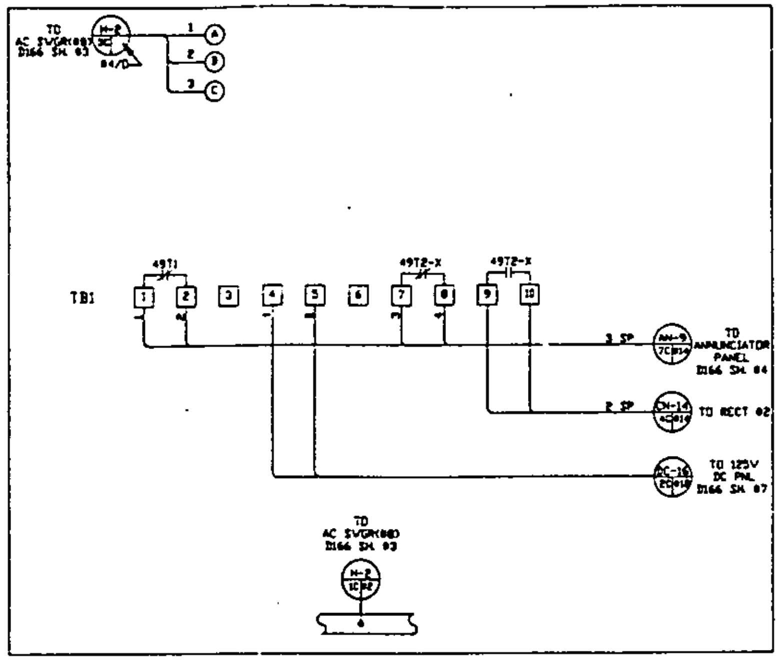
CUST. VMATA/SS-9
CONTRACT #121049
KINGSTON CONTRACTORS

TITLE EQUIPMENT INTERCONNECTION FOR MOUNT VERNON SQ. SUBSTATION

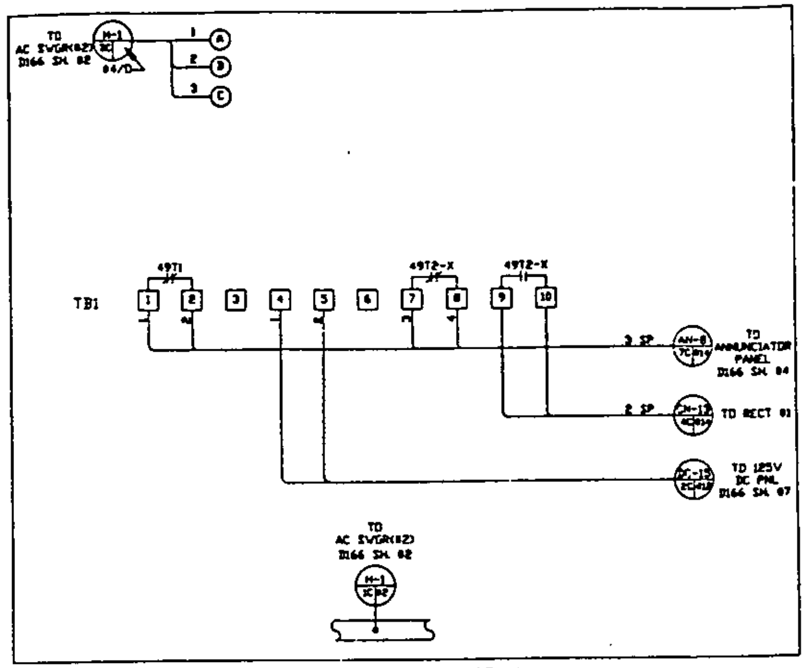
REV 1

DWG. NO. 4482-D166
SHEET 3 OF 7

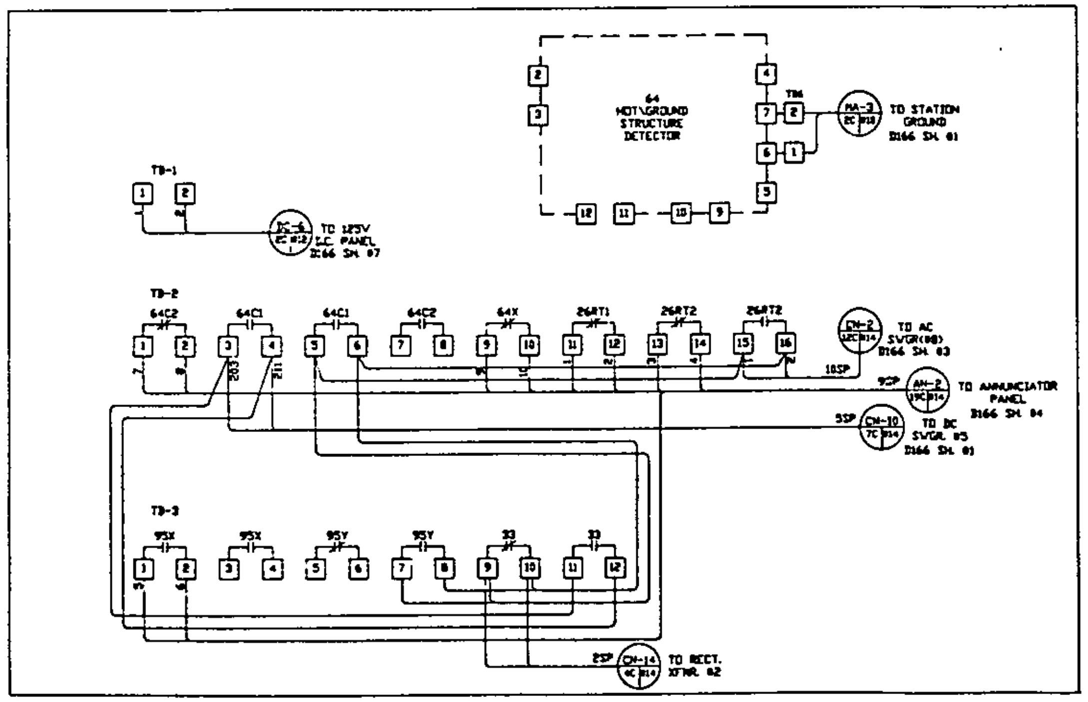
MAY 25 1990



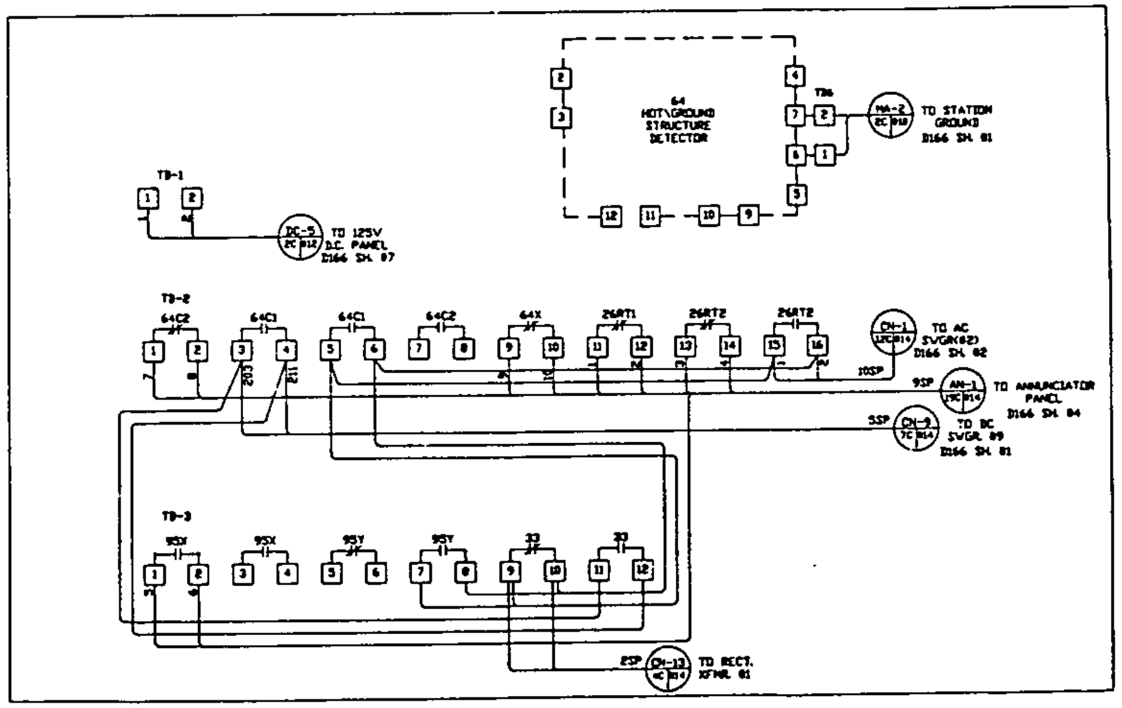
RECTIFIER TRANSFORMER #2



RECTIFIER TRANSFORMER #1



RECTIFIER #2



RECTIFIER #1

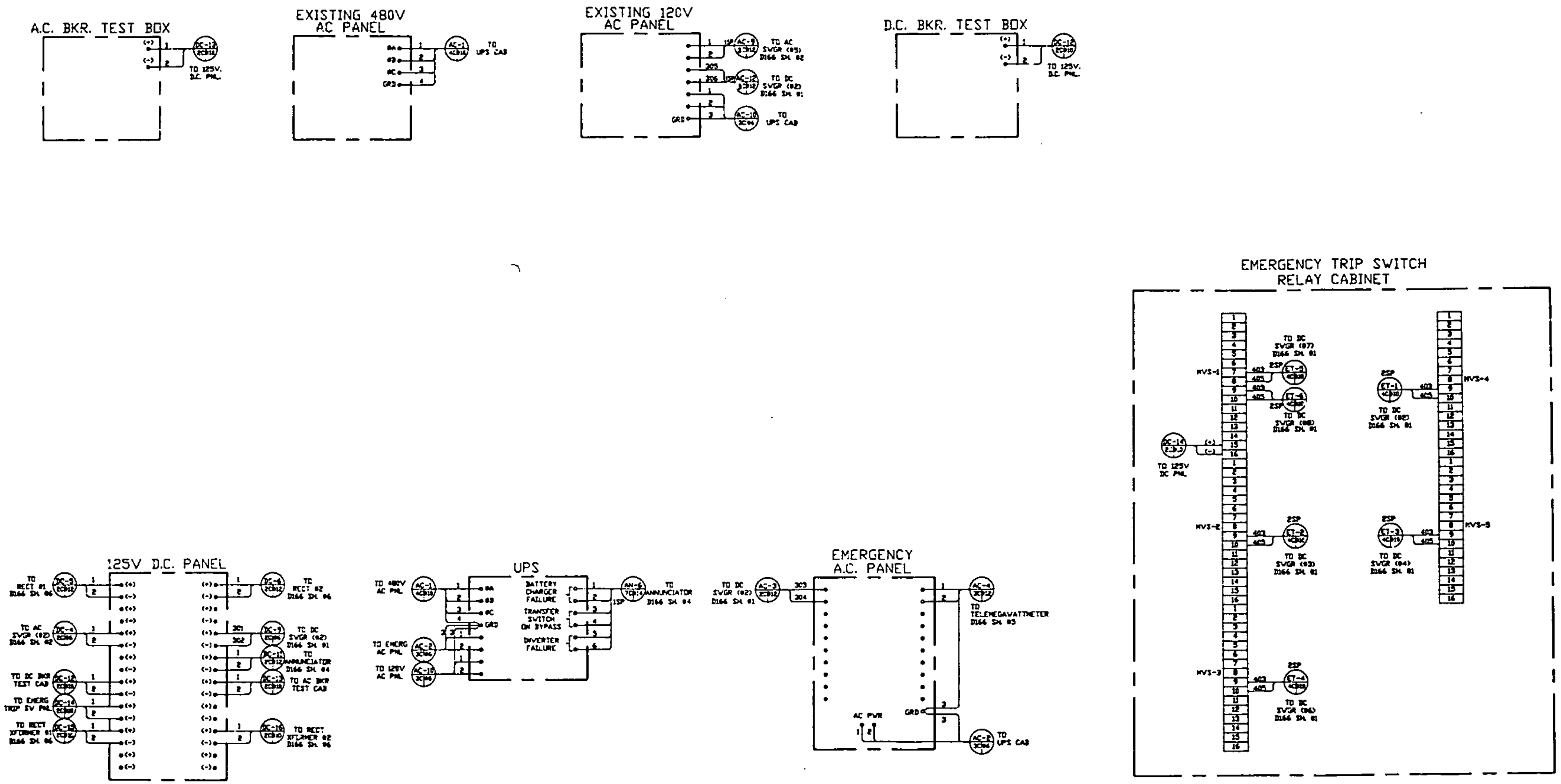
REVISIONS			
NO	BY	DATE	
1		[illegible]	REVISED WIRING AT RECTIFIERS & TRANSF PER TEST REV.

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-45, SS9-E-46, SS9-E-47, SS9-E-48, SS9-E-49, SS9-E-50, SS9-E-51, SS9-E-52, SS9-E-53, SS9-E-74.

MICROFILMED

DRAWN BY HRS	CONTROLLED POWER CORP.	TITLE EQUIPMENT INTERCONNECTION FOR MOUNT VERNON SQ. SUBSTATION	REV 1
DATE 3/20/89			
SCALE NTS	CUST. WMATA/SS-9		
CHK'D.	CONTRACT #1Z1049	DWG. NO. 4482-D166 SHEET 6 OF 7	
APP'D. BCN	KINGSTON CONTRACTORS		



REVISIONS

NO	BY	DATE
1	[illegible]	[illegible]

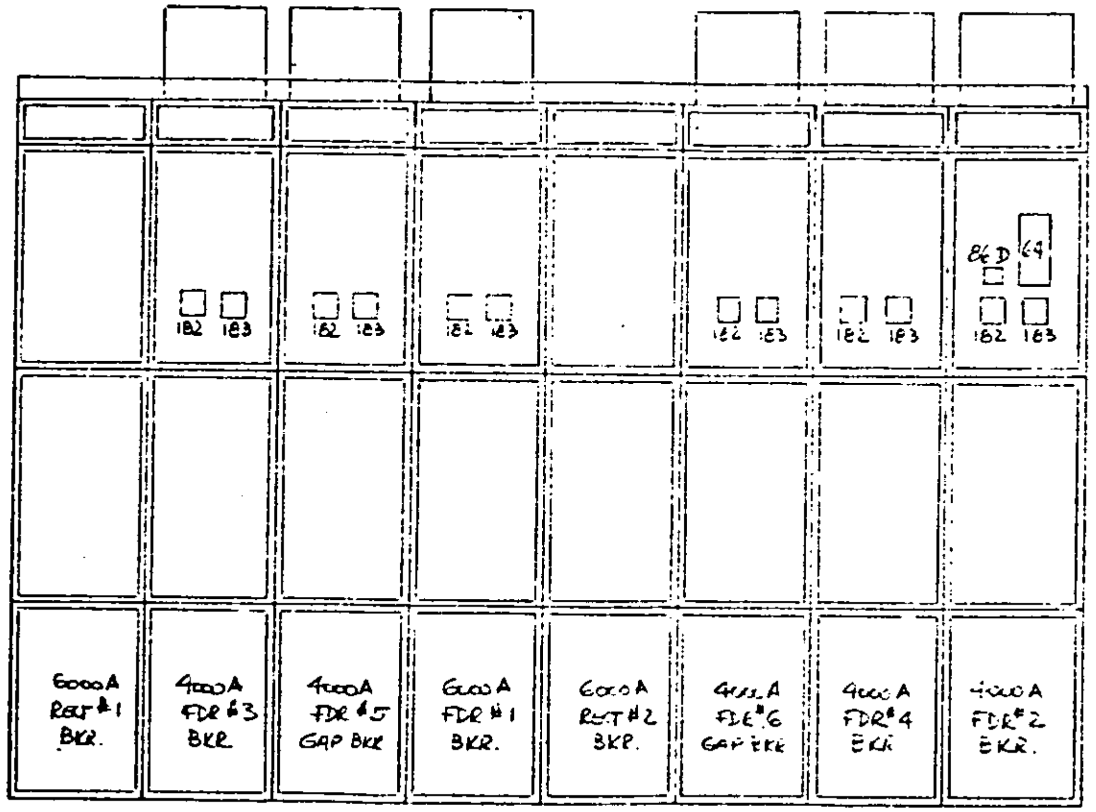
NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-9, SS9-E-45, SS9-E-46, SS9-E-47, SS9-E-48, SS9-E-49, SS9-E-50, SS9-E-51, SS9-E-52, SS9-E-53, SS9-E-74.

MICROFILMED

DRAWN BY R.R.R.	CONTROLLED POWER CORP.	TITLE EQUIPMENT INTERCONNECTION FOR MOUNT VERNON SQ. SUBSTATION
DATE 3/20/89		
SCALE NTS	CUST. WMATA/SS-9	
CHK'D.	CONTRACT #1Z1049	DWG. NO. 4482-D166 SHEET 7 OF 7
APP'D.	KINGSTON CONTRACTORS	

REV 1



REAR VIEW

FOR ELEVATION & SECTION VIEW
SEE DWG. No 4482-D14

MICRO FILMED 9-30 88

DRAWN BY FBB
DATE 9/20/88
SCALE
CHK'D
APP'D

[redacted]

CONTROLLED POWER CORP.
311 WETMORE AVE. S.E. • P. O. BOX [illegible]
MASSILLON, OHIO [illegible]

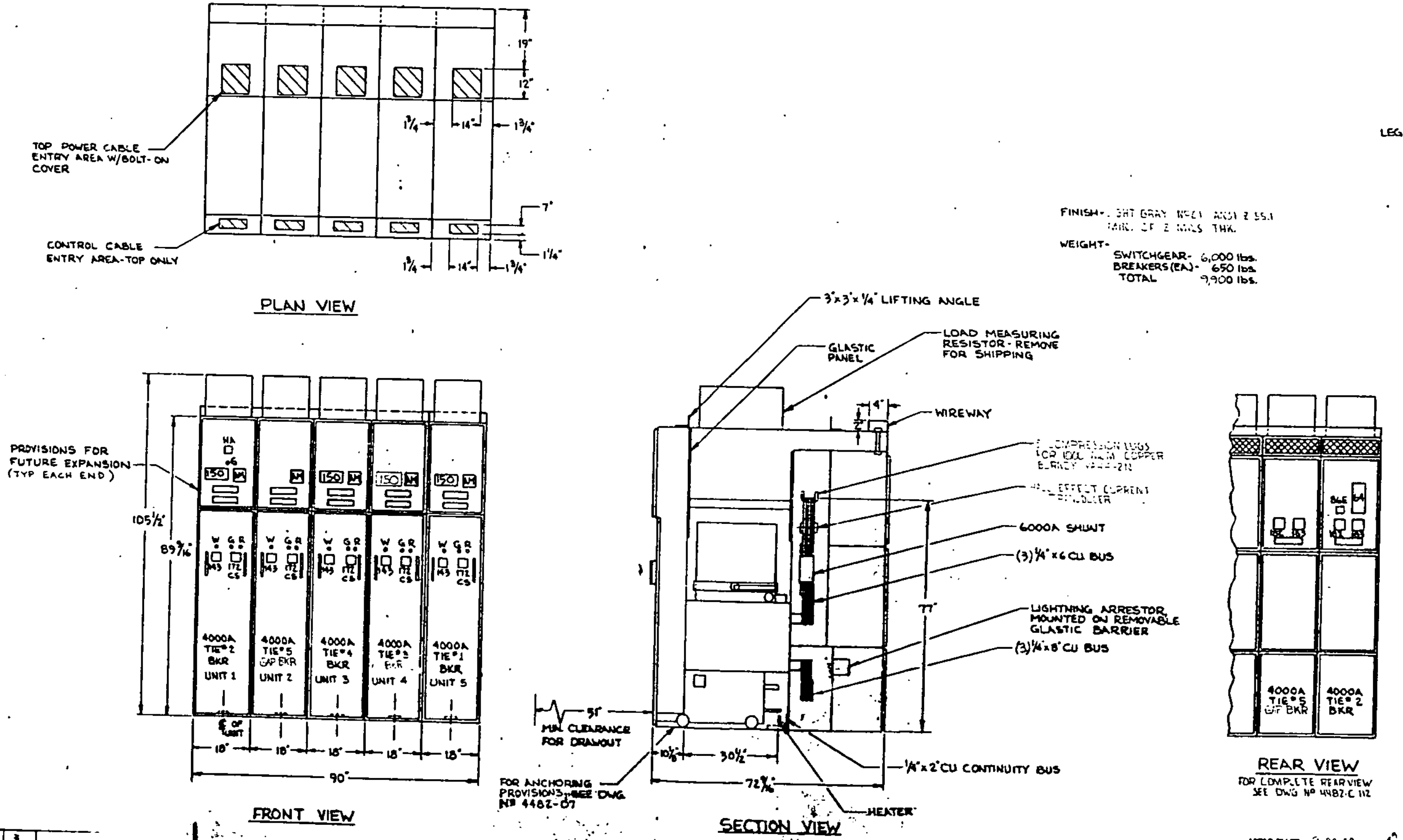
CUSTOMER WMATA/SS-9

TITLE REAR VIEW
TRACTION POWER SUBSTATION
MOUNT VERNON SQUARE
D.C. SWITCHGEAR

DWG. NO 4482-C111

REV.

MAY 25 1990



FINISH- LIGHT GRAY NO.61 ANSI Z 55.1
PAINT OF 2 MILS THK.

WEIGHT-

SWITCHGEAR-	6,000 lbs.
BREAKERS(EA)-	650 lbs.
TOTAL	9,900 lbs.

LEGEND-

172CS	BKR CONTROL SWITCH
W	WHITE LIGHT
AM	AMMETER
G	GREEN LIGHT
R	RED LIGHT
64	HIGH RESISTANCE GND RELAY
86E	LOCKOUT RELAY
143	REMOTE/LOCAL SWITCH
150	RATE OF RISE RELAY
162	CURRENT LOAD MEASURING RELAY
165	VOLTAGE LOAD MEASURING RELAY
HA	HEATER AMMETER

MICRO FILMED 7-29-88

REV. 1

PAB
5-18-88
NTS

CONTROLLED POWER CORP.

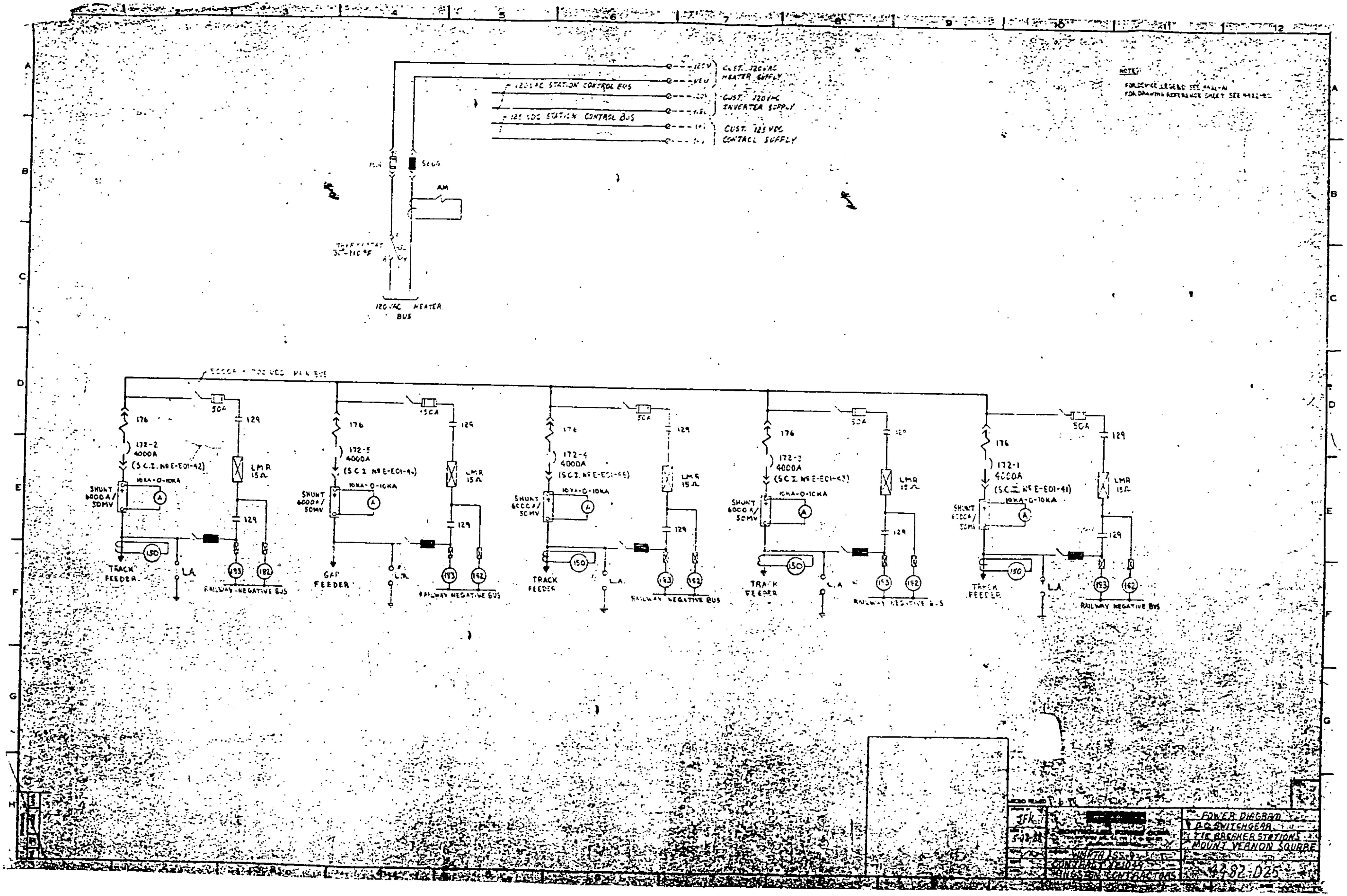
WMATA ISS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

ELEVATION OF
SUBSTATION EQUIPMENT SS-9
TIE BREAKER STATION
MOUNT VERNON SQUARE
D.C. SWITCHGEAR

4482-D15

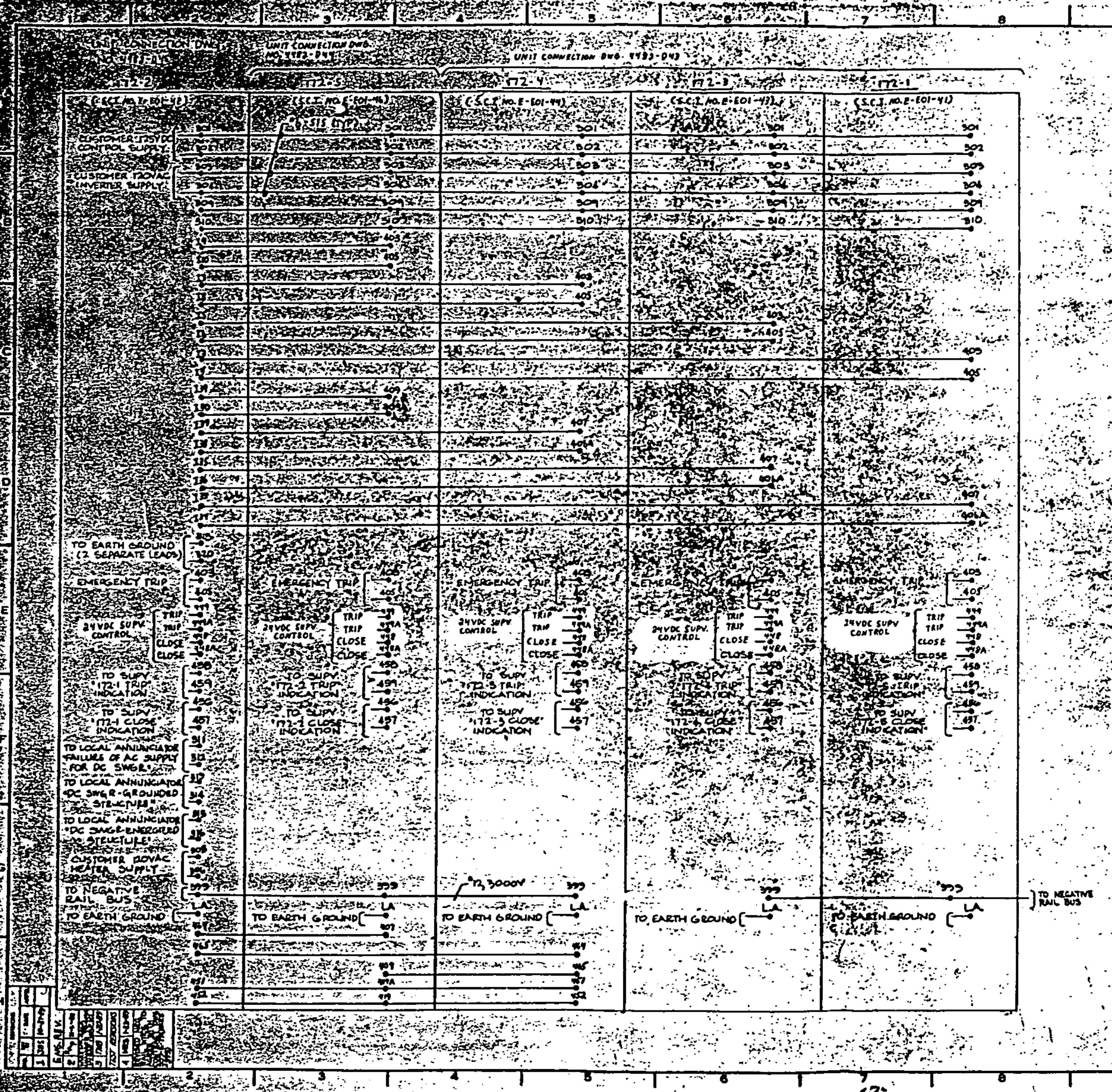
MAY 25 1990

D



JFK
5-12-88
[redacted]
WMATA 155
CONTRACT 1Z1034
JOHNSON CONTRACTORS
POWER DIAGRAM
D.C. SWITCHGEAR
TIE BREAKER STATIONS
MOUNT VERNON SQUARE
4282-D25

MAY 2 5 1990

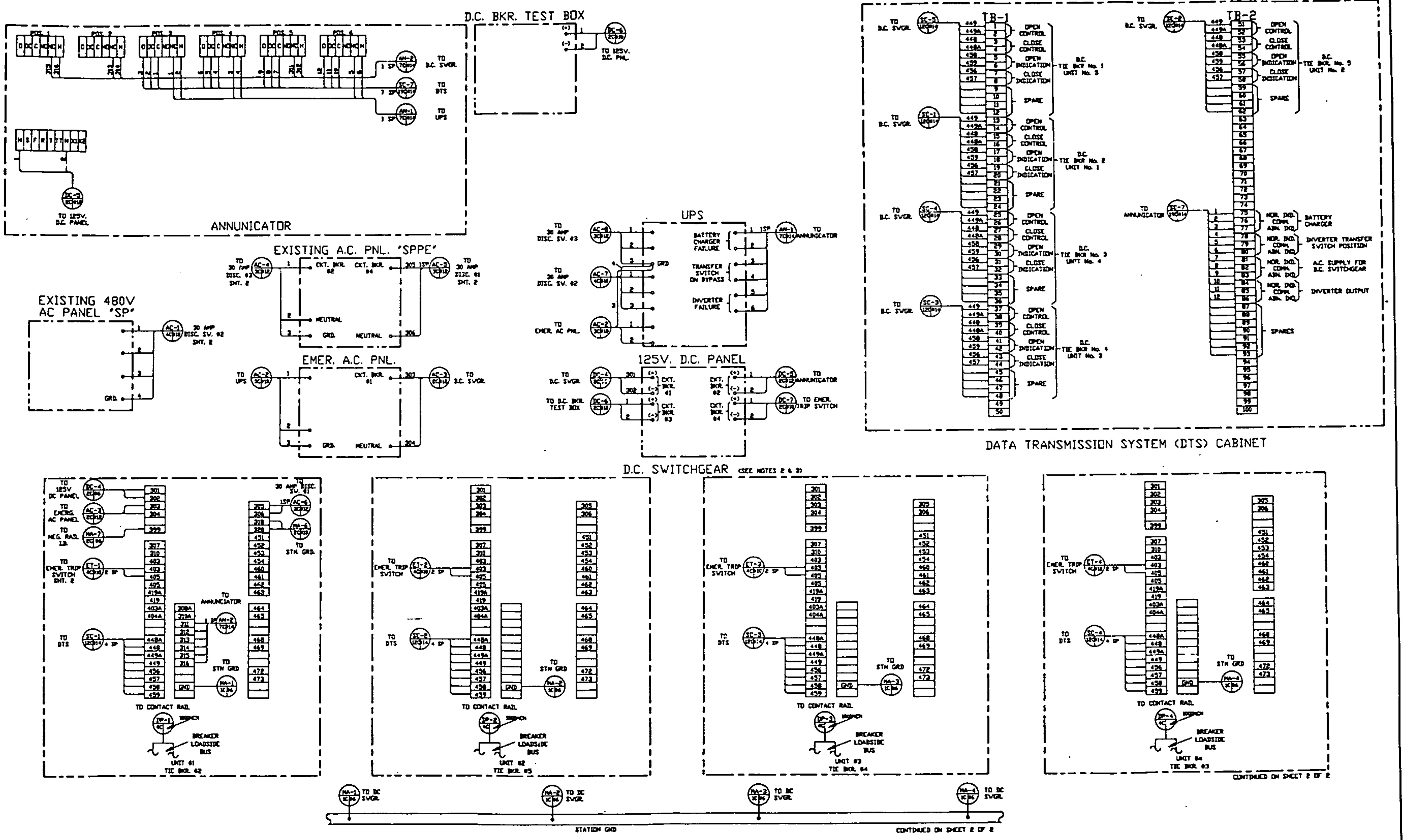


NOTES:
ALL WIRE NO. 14-SIS UNLESS NOTED

J.R.S.	CONTROLLED POWER CORP.	INTERCONNECTION DIAGRAM
9-26-88		DC SWITCHGEAR
		TIE BREAKER STATIONS
		MOUNT VERNON SQUARE
	WMATA / SS-4	
	CONTRACT 1E1049	4482-D35
	KINGSTON CONTRACTORS	

REV 4

MAY 25 1990



REVISIONS			
NO.	BY	DATE	
1	[illegible]	5/27/90	CUSTOMER APPROVAL REVISIONS

NOTES:

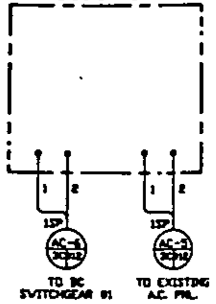
1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-41, SS9-E-42, SS9-E-43, SS9-E-44, SS9-E-74.
2. ALL CUSTOMER CONNECTION TO D.C. SWITCHGEAR MADE ON FRONT METERING COMPARTMENT TERMINAL BLOCKS. (WITH EXCEPTION OF POWER CABLE CONNECTIONS)
3. SPARE TERMINALS IN DC SWITCHGEAR ARE SHOWN AS BLANKS.

MICROFILMED

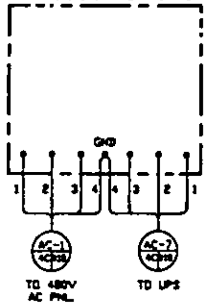
DRAWN BY J.H.S.	[redacted] CONTROLLED POWER CORP.	TITLE	REV 1
DATE 4/7/89		EQUIPMENT INTERCONNECTION MOUNT VERNON SQUARE TIE BREAKER STATION	
SCALE NTS	CUST. VMATA/SS-9		
CHK'D. RU	CONTRACT #1Z1049	DWG. NO. 4482-D49	
APP'D. SK	KINGSTON CONTRACTORS	SHEET 1 OF 2	

MAY 25 1990

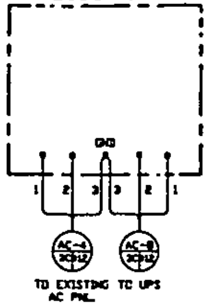
30 AMP DISC. SWITCH #1



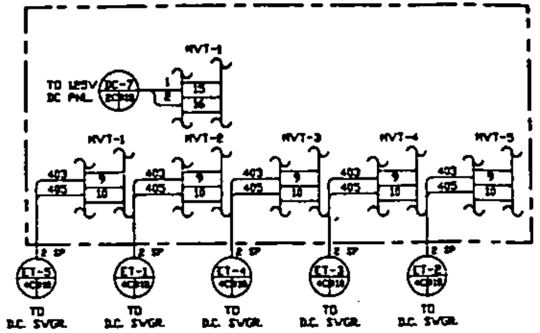
30 AMP DISC. SWITCH #2



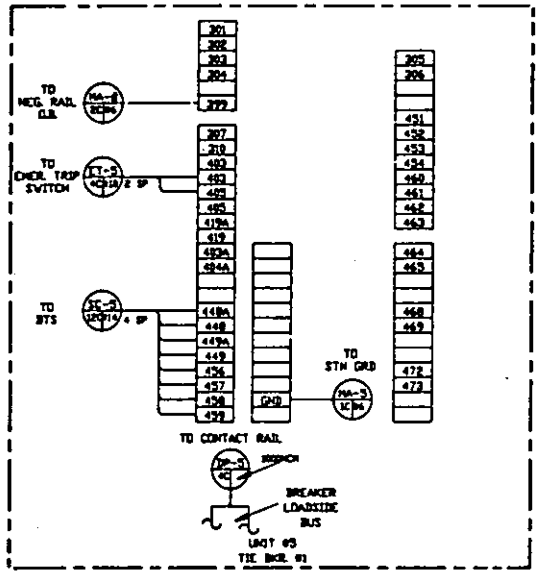
30 AMP DISC. SWITCH #3



EMERGENCY TRIP SWITCH PANEL



D.C. SWITCHGEAR (SEE NOTES 2 & 3)



CONTINUED FROM SHEET 1 OF 2

CONTINUED FROM SHEET 1 OF 2

REVISIONS			
NO	BY	DATE	
1	[illegible]	2/27/90	CUSTOMER APPROVAL REVISIONS

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-41, SS9-E-42, SS9-E-43, SS9-E-44, SS9-E-74.
2. ALL CUSTOMER CONNECTION TO D.C. SWITCHGEAR MADE ON FRONT METERING COMPARTMENT TERMINAL BLOCKS. (WITH EXCEPTION OF POWER CABLE CONNECTIONS)
3. SPARE TERMINALS IN DC SWITCHGEAR ARE SHOWN AS BLANKS.

MICROFILMED

DRAWN BY J.H.S.
DATE 4/6/89
SCALE NTS
CHK'D. BCW
APP'D. BCW

[redacted]
CONTROLLED POWER CORP.

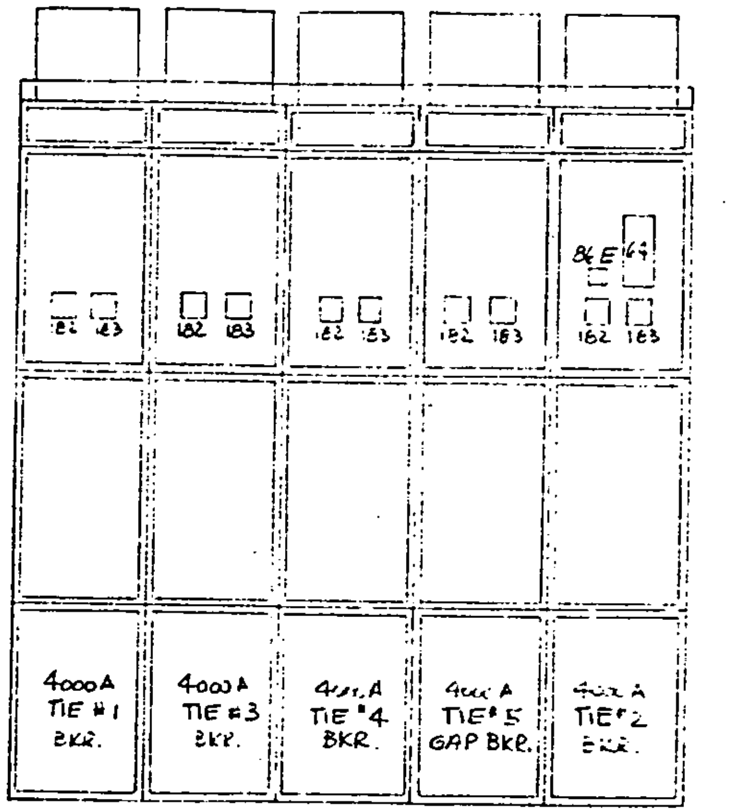
CUST. WMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE
EQUIPMENT INTERCONNECTION
MOUNT VERNON SQUARE
TIE BREAKER STATI'N

DWG. NO. 4482-D49
SHEET 2 OF 2

REV 1

MAY 25 1990



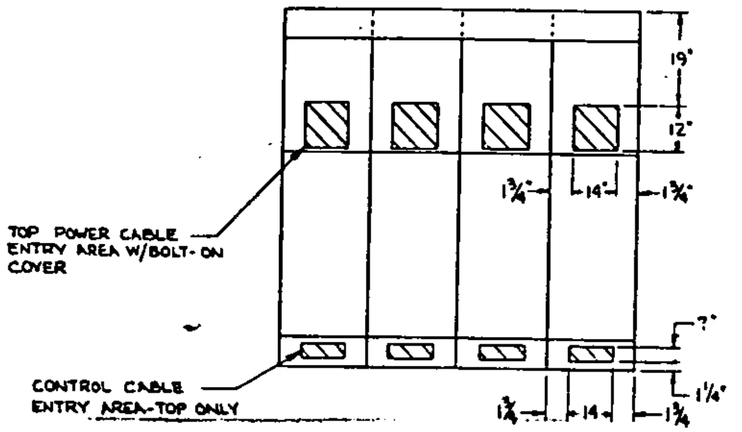
REAR VIEW

FOR ELEVATION & SECTION VIEW
SEE DWG Nº 4482-D15

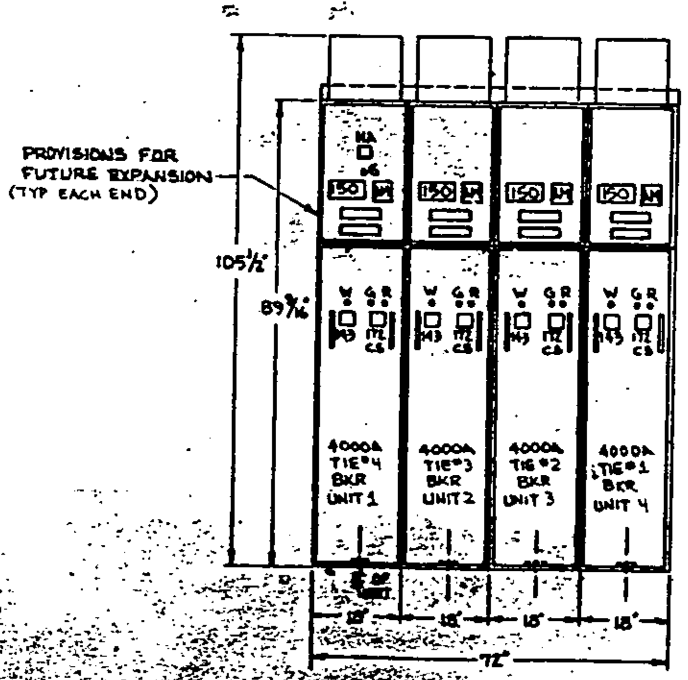
MICRO FILMED 9-30-88

DRAWN BY FBB	[redacted] **CONTROLLED POWER CORP.** 211 WETMORE AVE. S.E. • P.O. BOX 550 MASSILLON, OHIO	REAR VIEW
DATE 9/20/88		TIE BREAKER STATION MOUNT VERNON SQUARE D.C. SWITCHGEAR
SCALE	CUSTOMER WMATA / SS-9	
CHK'D		DWG. NO. 4482-C112
APP'D		

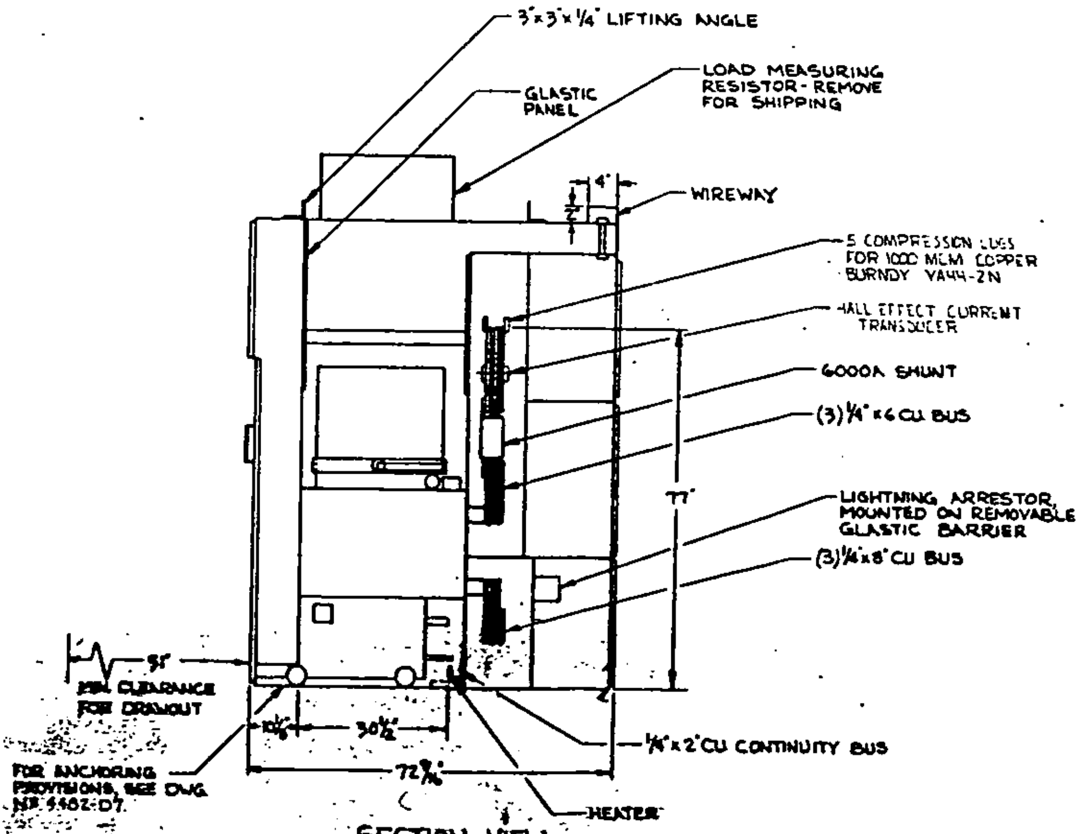
REV



PLAN VIEW



FRONT VIEW

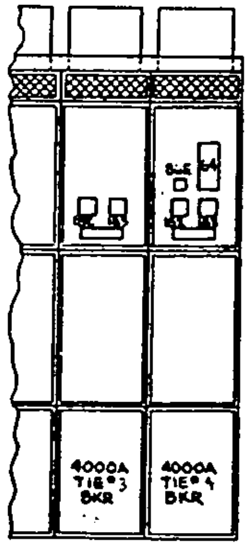


SECTION VIEW

FINISH-LIGHT GREY NO 61 ANSI Z 55.1
MINIMUM OF 2 MILS THK.

WEIGHT-
SWITCHGEAR- 4,800 lbs.
BREAKERS(EA)- 650 lbs.
TOTAL -7,400 lbs.

LEGEND-
172CS-BKR CONTROL SWITCH
W -WHITE LIGHT
AM -AMMETER
G -GREEN LIGHT
R -RED LIGHT
64 -HIGH RESISTANCE GND RELAY
86E-LOCKOUT RELAY
143 -REMOTE/LOCAL SWITCH
150 -RATE OF RISE RELAY
162 -CURRENT LOAD MEASURING RELAY
163 -VOLTAGE LOAD MEASURING RELAY
HA -HEATER AMMETER



REAR VIEW
FOR COMPLETE REAR VIEW SEE DWG NO 4482-C113

MICRO FILMED 9-27-88 C

REV. 1

FAB
5-18-88
NTS

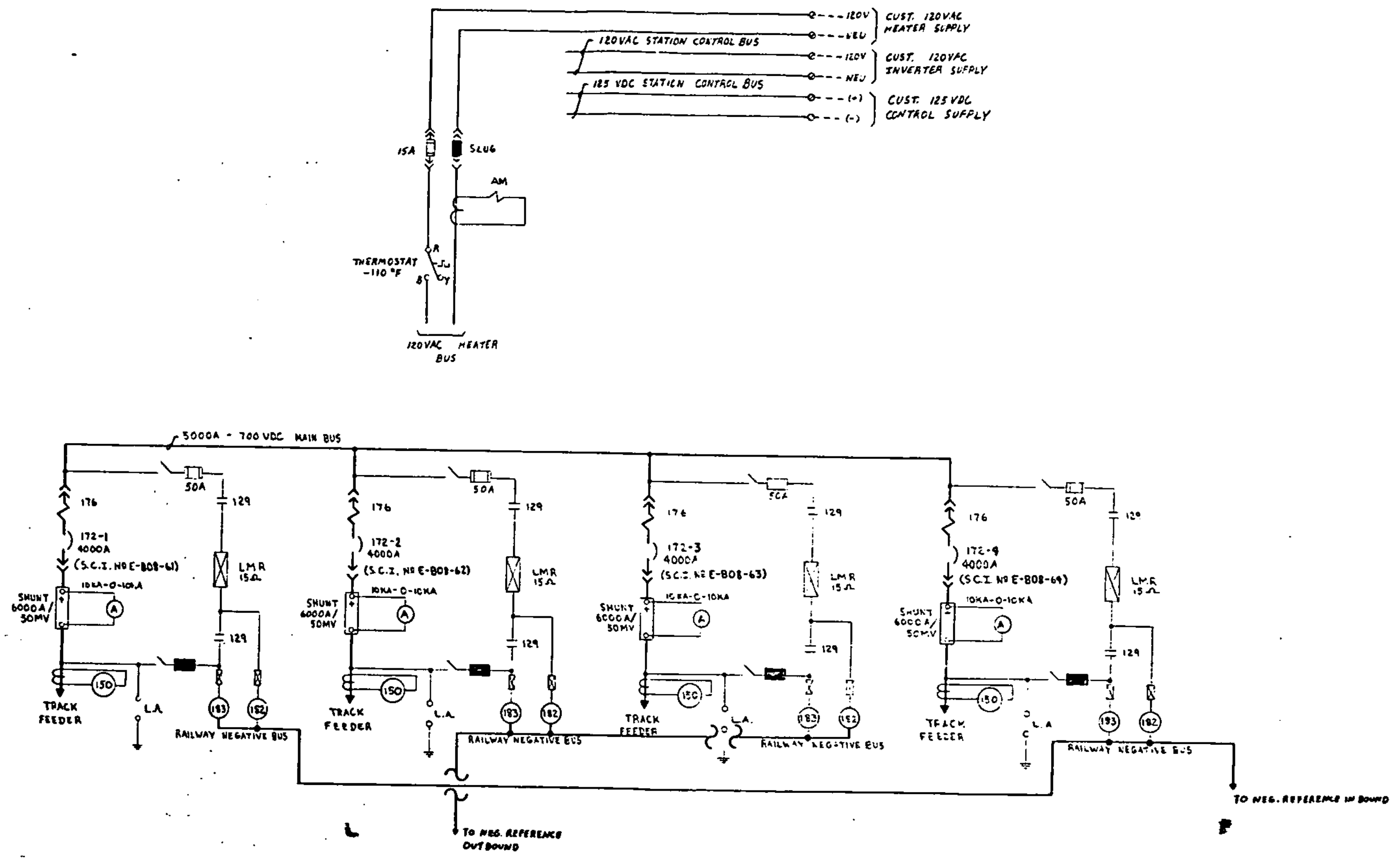
CONTROLLED POWER CORP.

WMATA SS-9
CONTRACT # 121049
KINGSTON CONTRACTORS

ELEVATION OF
SUBSTATION EQUIPMENT SS-9
TIE BREAKER STATION
NOYES LANE
D.C. SWITCHGEAR
4482-D16

MAY 25 1990

D



NOTES:

FOR DEVICE LEGEND SEE 4482-A1
FOR DRAWING REFERENCE SHEET SEE 4482-B2

MAY 25 1990

MICRO FILMED 10-4-95

C 1

REV.

JFK
5-18-88

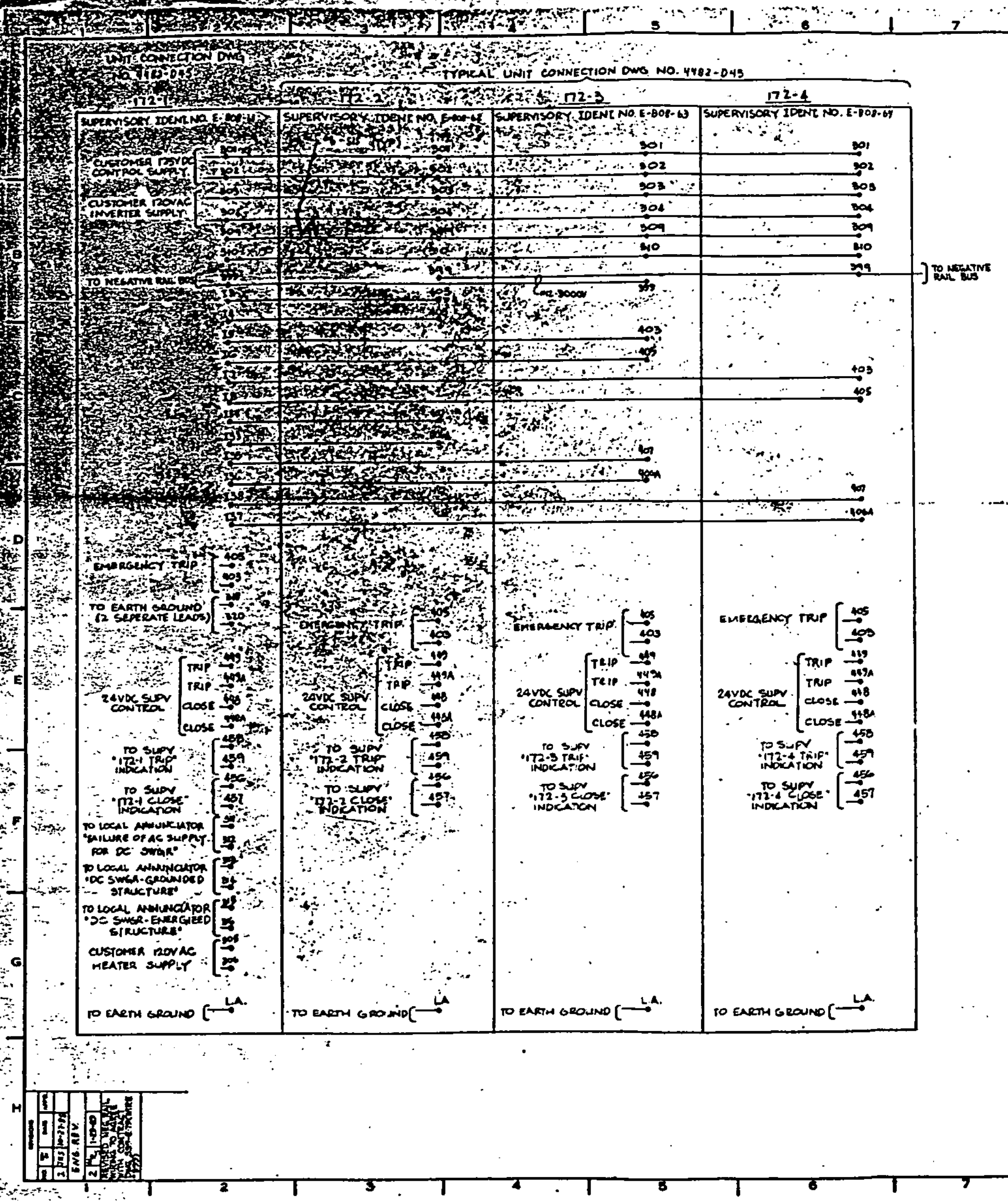
CONTROLLED POWER CORP.

WMATA / SS-9
CONTRACT 121049
KINGSTON CONTRACTORS

POWER DIAGRAM
DC SWITCHGEAR
TIE BREAKER STATIONS
NOYES LANE

4492-D26

D



NOTES:
ALL WIRE NO 14 -SIS UNLESS NOTED.

MAY 25 1990

MICRO FILMED

REV 2

JRS.

CONTROLLED POWER CORP.

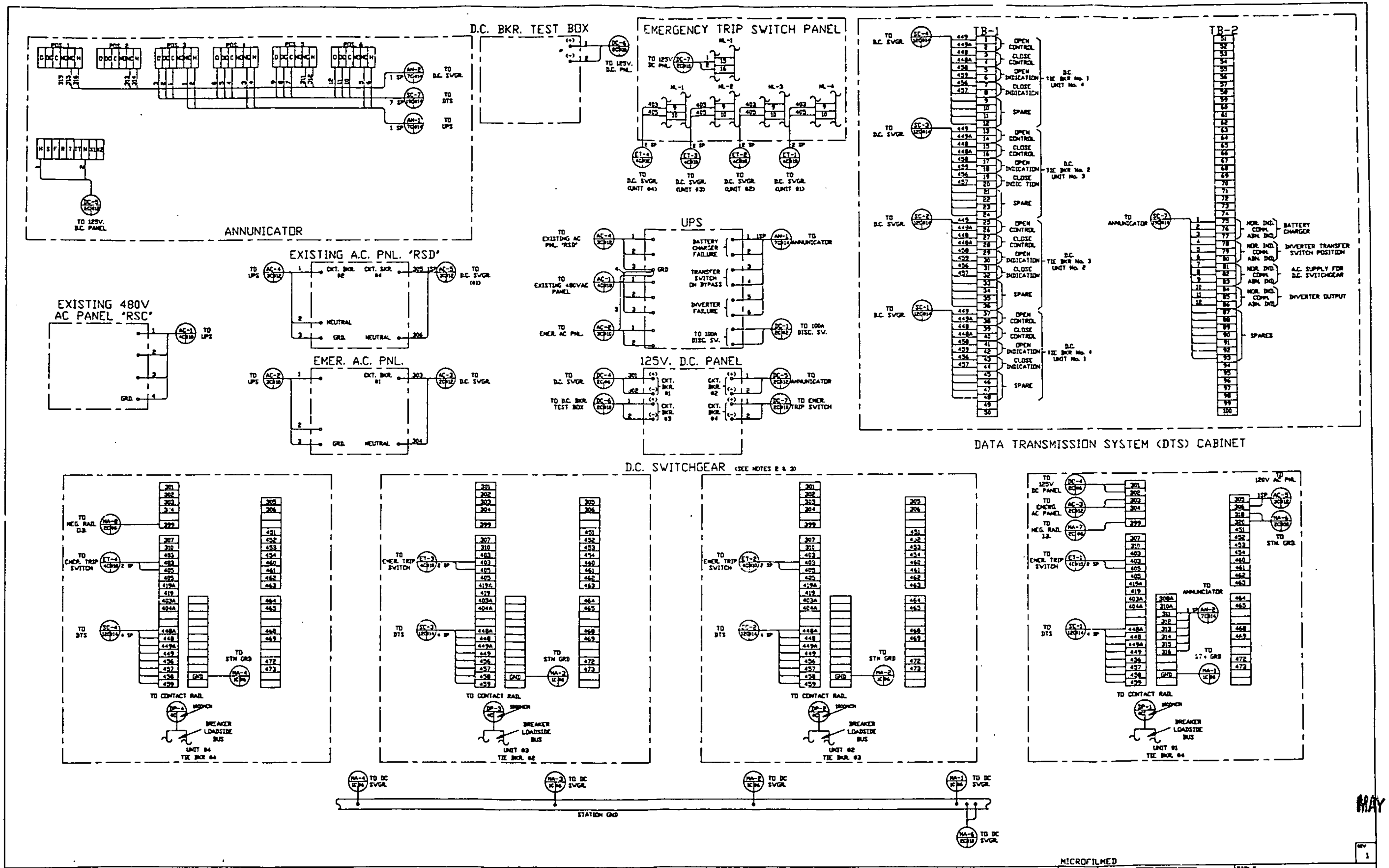
WMATA/155-9

CONTRACT 121049

KINGSTON CONTRACTORS

INTERCONNECTION DIAGRAM
DC SWITCHGEAR
TIE BREAKER STATIONS
NOYES LANE

4482-D36



MAY 2 5 1990

REV 1

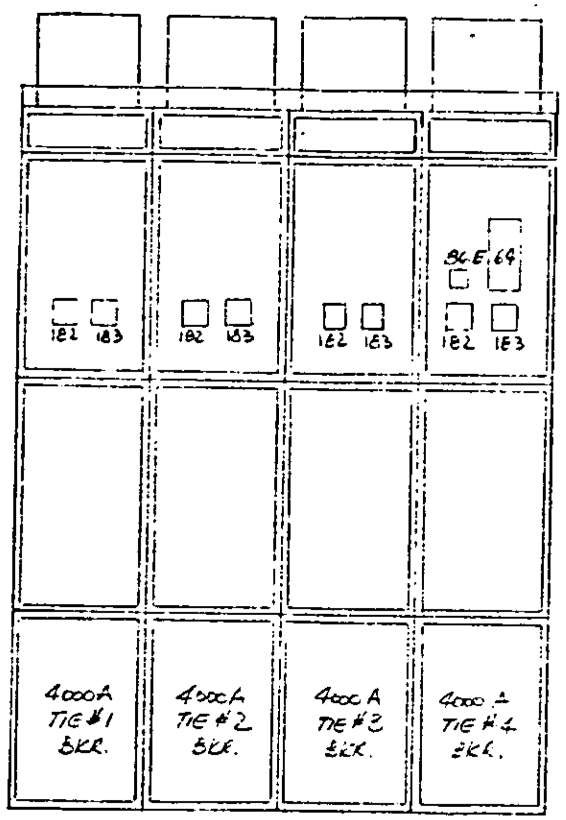
MICROFILMED

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-11, SS9-E-12, SS9-E-13, SS9-E-14, SS9-E-72.
2. ALL CUSTOMER CONNECTION TO D.C. SWITCHGEAR MADE ON FRONT METERING COMPARTMENT TERMINAL BLOCKS. (WITH EXCEPTION OF POWER CABLE CONNECTIONS)
3. SPARE TERMINALS IN DC SWITCHGEAR ARE SHOWN AS BLANKS.

REVISIONS			
NO	BY	DATE	
1	[illegible]	2/27/90	CUSTOMER APPROVAL REVISIONS

DRAWN BY JMS	CONTROLLED POWER CORP.	TITLE EQUIPMENT INTERCONNECTION NOYES LANE TIE BREAKER STATION
DATE 4/6/89		
SCALE NTS	CUST. WMATA/SS-9	
CHK'D. [illegible]	CONTRACT 8121049	DWG. NO. 4482-D47
APP'D. [illegible]	KINGSTON CONTRACTORS	



REAR VIEW

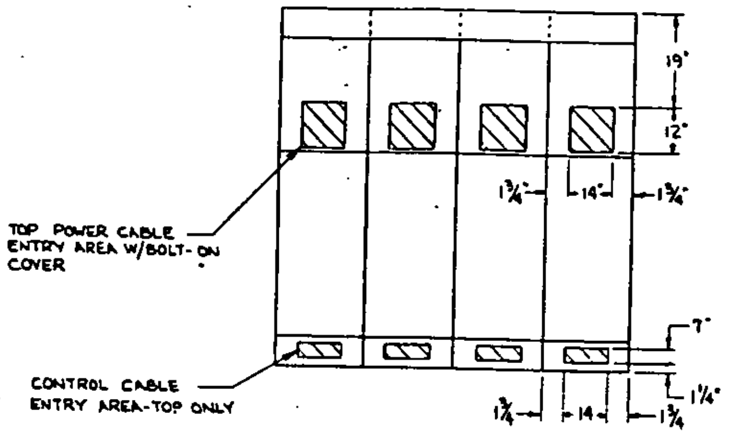
FOR ELEVATION & SECTION VIEW
SEE DWG № 4482-D16

MAY 25 1990

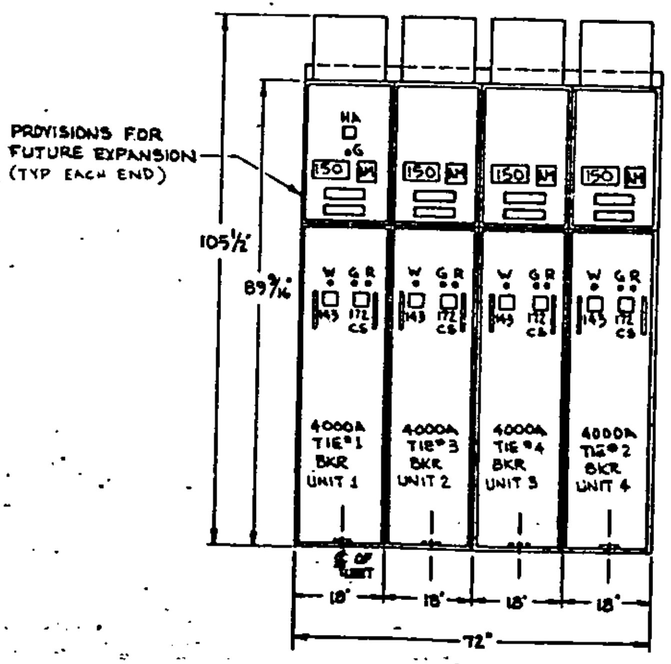
MICRO FILMED 9-30-88

DRAWN BY FBB	[redacted] **CONTROLLED POWER CORP.** 211 WETMORE AVE. S.E. • P. O. BOX [illegible] MASSILLON, OHIO [illegible]	TITLE REAR VIEW
DATE 9/20/88		TIE BREAKER STATION NOYES LANE D.C. SWITCHGEAR
SCALE	CUSTOMER WMATA / SS-9	
CHK'D		DWG. NO. 4482-C13
APP'D		

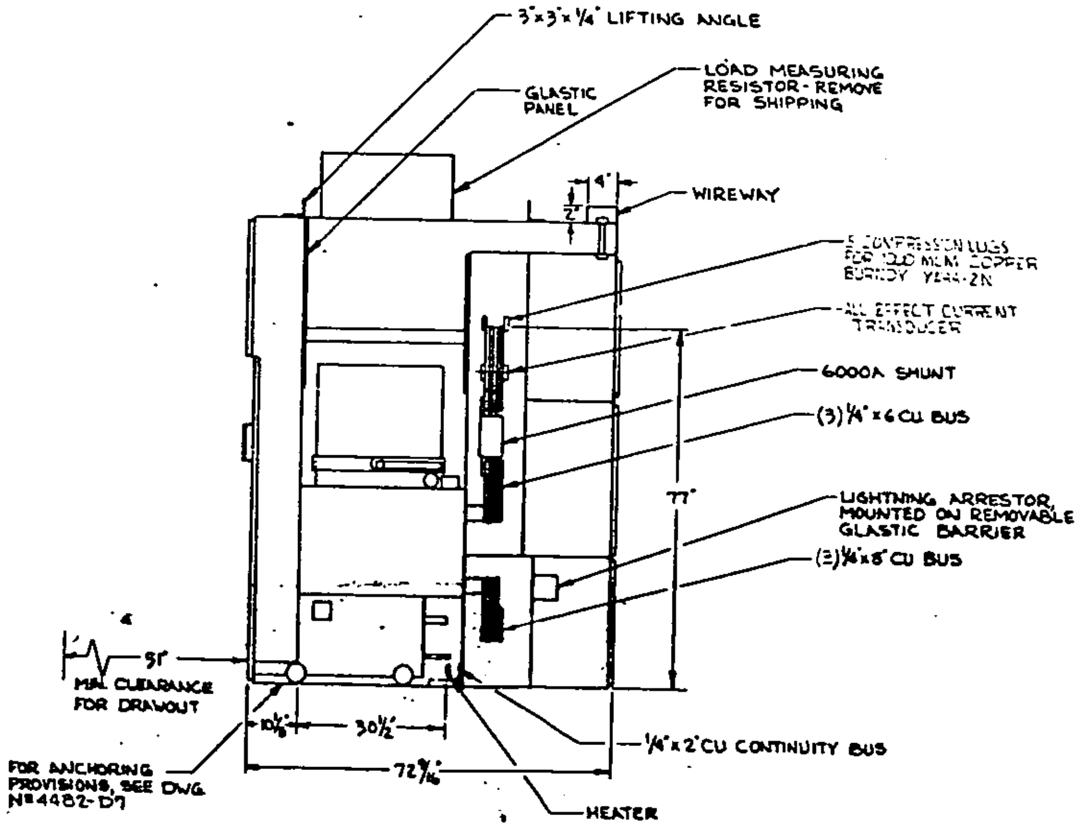
REV.



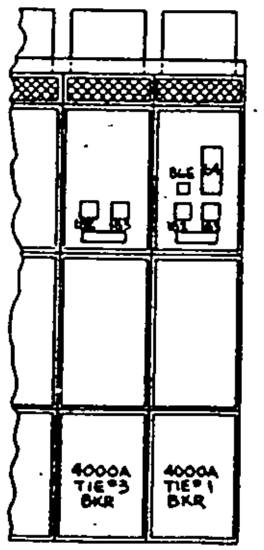
PLAN VIEW



FRONT VIEW



SECTION VIEW



REAR VIEW

FOR COMPLETE REAR VIEW SEE DWG N° 4482-C114

FINISH-LIGHT GRAY ASA 61 ANSI Z 55.1 MINIMUM OF 2 MILS THK.

WEIGHT-
SWITCHGEAR- 4,800 lbs.
BREAKERS (EA)- 650 lbs.
TOTAL -7,400 lbs.

LEGEND-
172CS - BKR CONTROL SWITCH
W - WHITE LIGHT
AM - AMMETER
G - GREEN LIGHT
R - RED LIGHT
64 - HIGH RESISTANCE GND RELAY
86E - LOCKOUT RELAY
143 - REMOTE/LOCAL SWITCH
150 - RATE OF RISE RELAY
182 - CURRENT LOAD MEASURING RELAY
183 - VOLTAGE LOAD MEASURING RELAY
HA - HEATER AMMETER

MAY 25 1990

MICRO FILMED 4-24-92

C 1

REV. 1

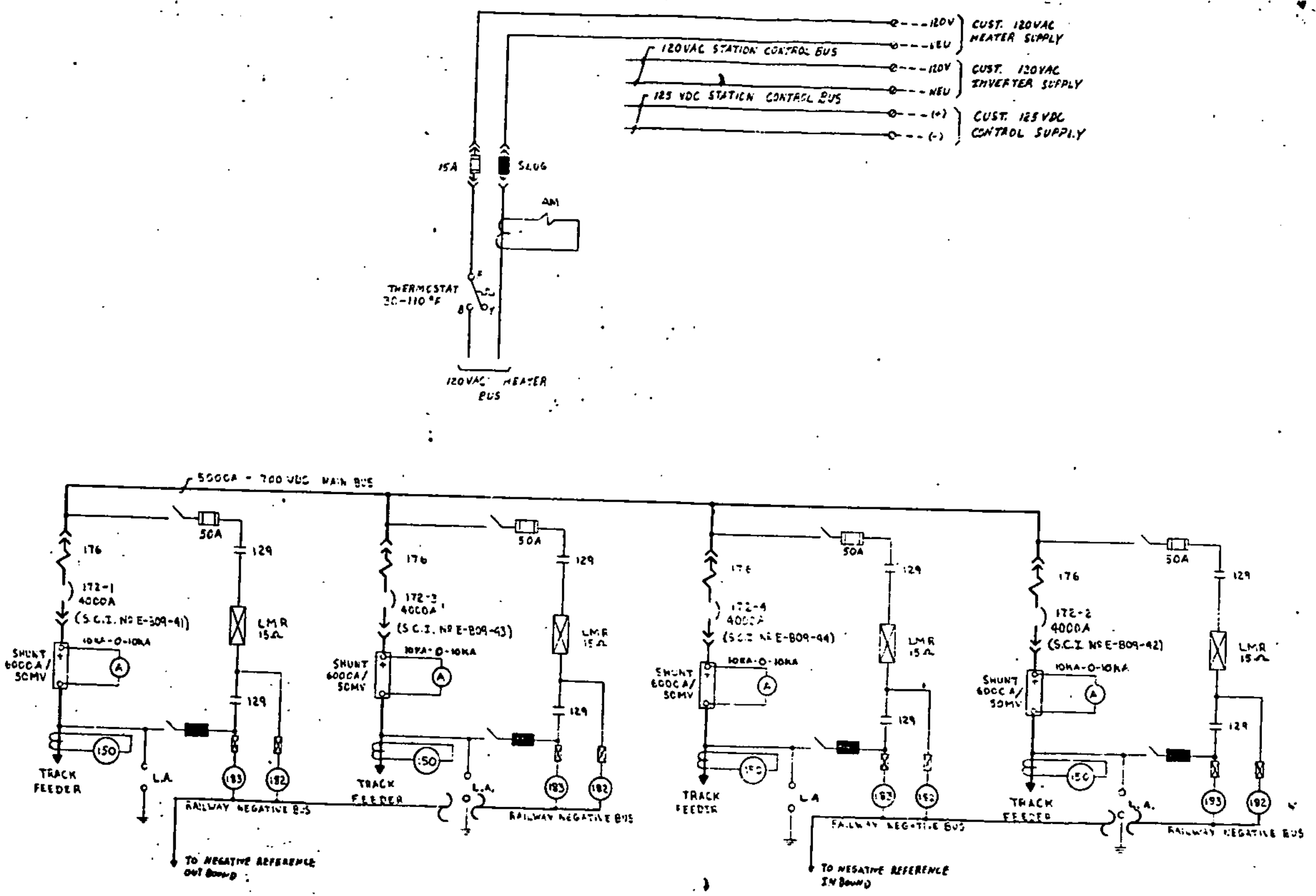
PAB
5-18-88
NTS
CONTROLLED POWER CORP
WMATA / SS-9
CONTRACT #121049
KINGSTON CONTRACTORS

ELEVATION OF
SUBSTATION EQUIPMENT SS-9
TIE BREAKER STATION
HILDAROSE DRIVE
D.C. SWITCHGEAR

4482-D17

1 | 12.6 | 9.21.88 | REVISIONS AS C CUSTOMER'S APPROVAL DRAWINGS

D



NOTES:

FOR DEVICE LEGEND SEE 4482-A1
FOR DRAWING REFERENCE SHEET SEE 4482-B2

MAY 25 1990

MICRO FILMED 10-4-88

C !

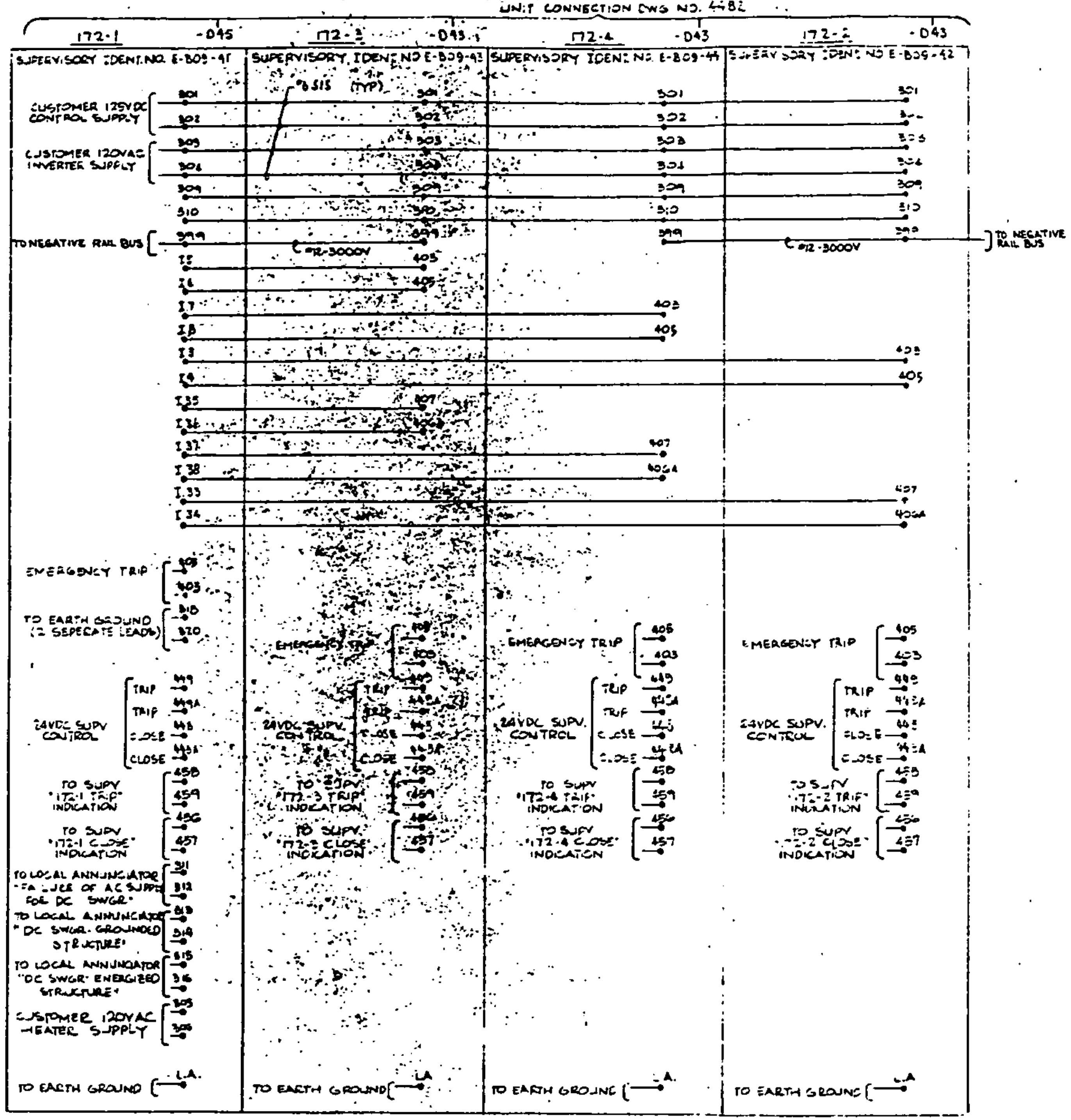
JFK
5-15-88

[redacted]
CONTROLLED POWER CORP

WMATA/SS-9
CONTRACT 1Z1049
KINGSTON CONTRACTORS

POWER DIAGRAM
DC SWITCHGEARS
TIE BREAKER STATIONS
HILDAROSE DRIVE

4482-D27



NOTES:
ALL WIRE NO 14-SIS UNLESS NOTED.

MAY 2 5 1990

REV 2

MICRO FILMED

CONTROLLED POWER CORP.

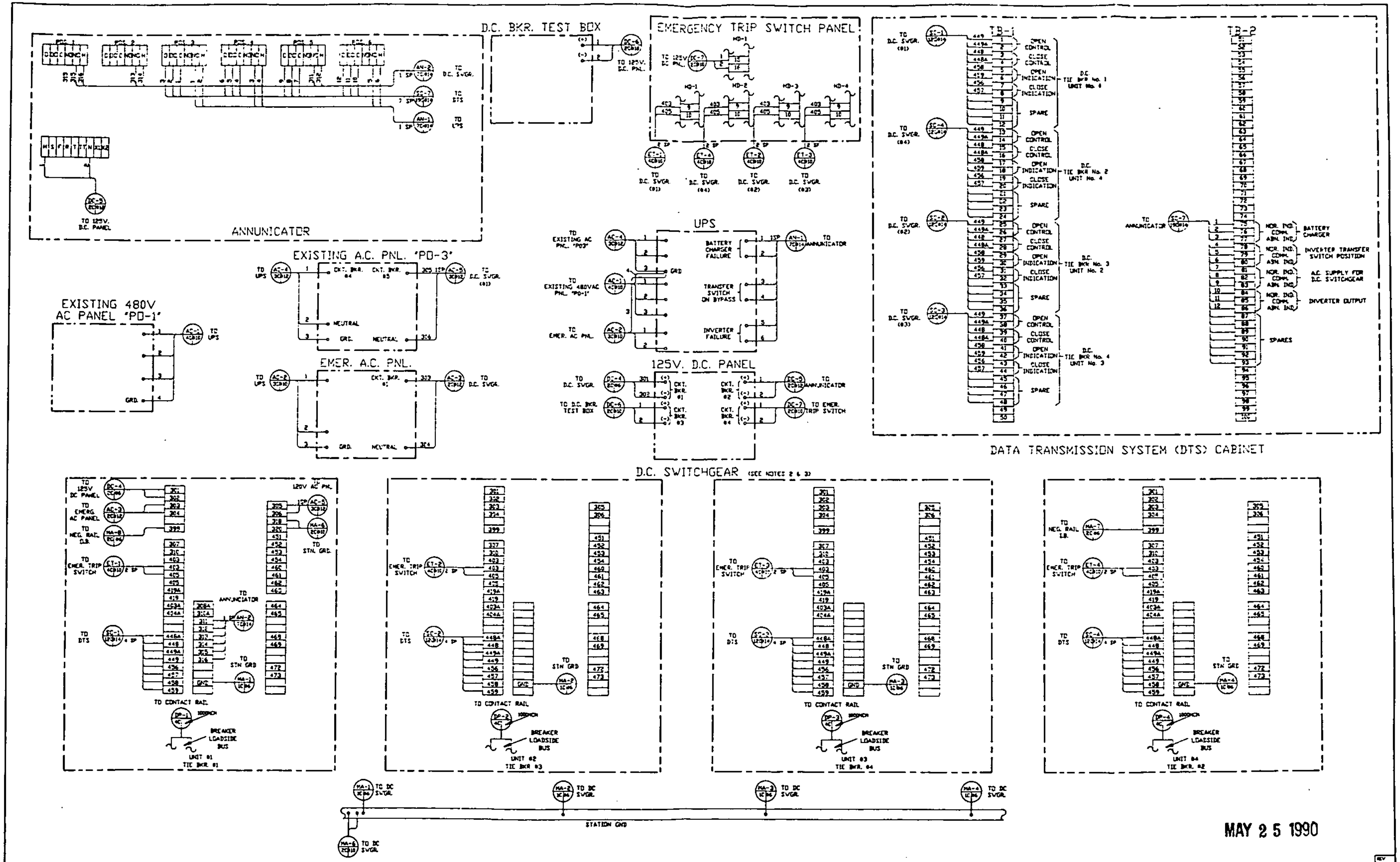
WMATA SS-5
CONTRACT 1Z1C43
NACTON CONTRACTORS

INTERCONNECTION DIAGRAM
DC SWITCHGEAR
DC BREAKER STATIONS
MCAROSE DRIVE

4482-D37

ENG. REV.

REVISED MAG. CUL. TO AGREE WITH EXIST. RAIL WIRES



MAY 2 5 1990

MICROFILMED

REVISIONS			
NO	BY	DATE	
1	[illegible]	2/27/90	CUSTOMER APPROVAL REVISIONS

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-24, SS9-E-25, SS9-E-26, SS9-E-27, SS9-E-72.
2. ALL CUSTOMER CONNECTION TO D.C. SWITCHGEAR MADE ON FRONT METERING COMPARTMENT TERMINAL BLOCKS. (WITH EXCEPTION OF POWER CABLE CONNECTIONS)
3. SPARE TERMINALS IN DC SWITCHGEAR ARE SHOWN AS BLANKS.

DRAWN BY J.H.S.
DATE 4/6/89
SCALE NTS
CHK'D. [illegible]
APP'D. [illegible]

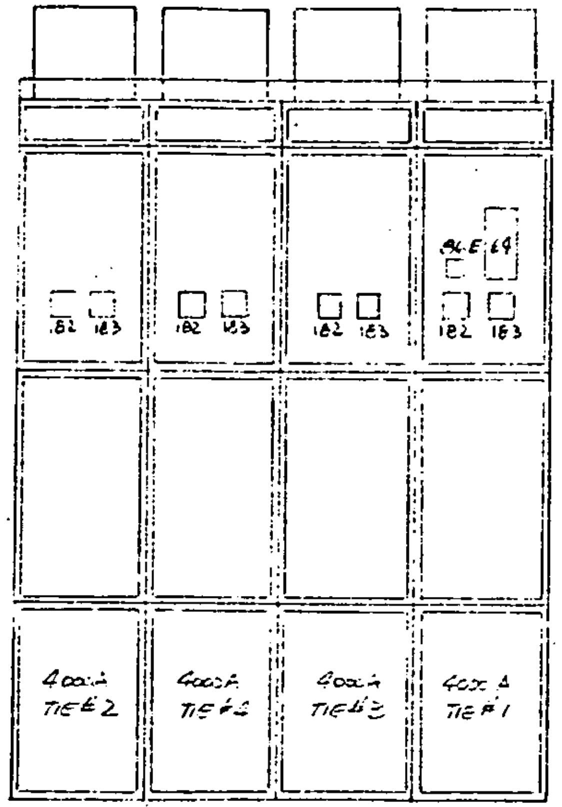
CONTROLLED POWER CORP.

CUST. WMATA/SS-9
CONTRACT #121049
KINGSTON CONTRACTORS

TITLE
EQUIPMENT INTERCONNECTION
HILDARGSE DRIVE TIE BREAKER
STATION

DWG. NO. 4482-D48

REV 1



REAR VIEW

FOR ELEVATION & SECTION VIEW
SEE DWG № 4482-D17

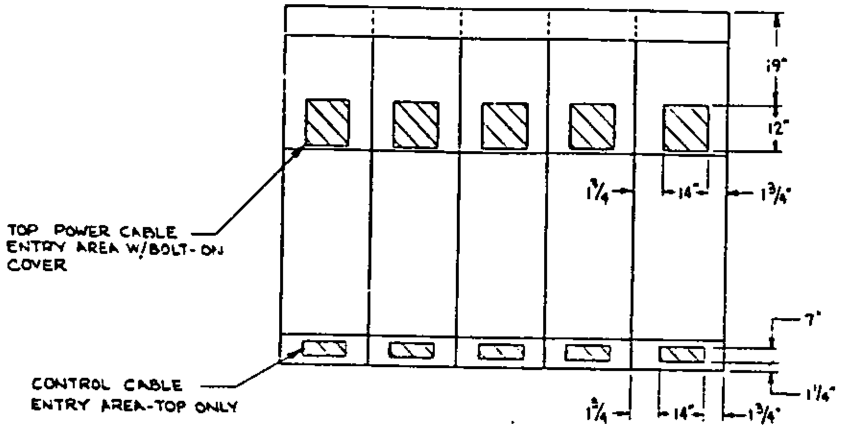
B

MAY 25 1990

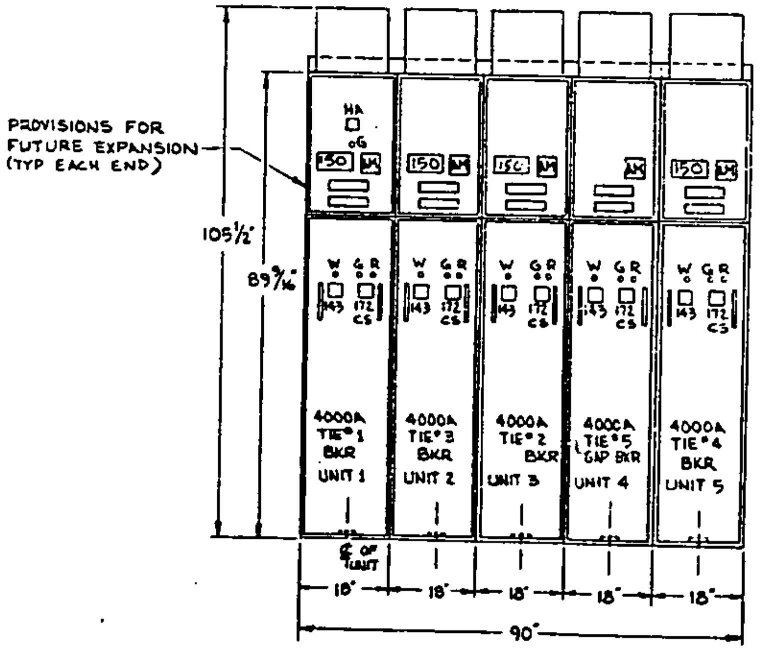
MICRO FILMED 9-30-88

DRAWN BY FBB	[redacted] CONTROLLED POWER CORP. 211 WETMORE AVE. S.E. • P.O. BOX [illegible] MASSILLON, OHIO [illegible]	TITLE REAR VIEW
DATE 9/20/83		TIE BREAKER STATION HILDAROSA DRIVE
SCALE	CUSTOMER WMATA/SS-9	D.C. SWITCHGEAR
CHK'D		DWG. NO. 4482-C14
APP'D		

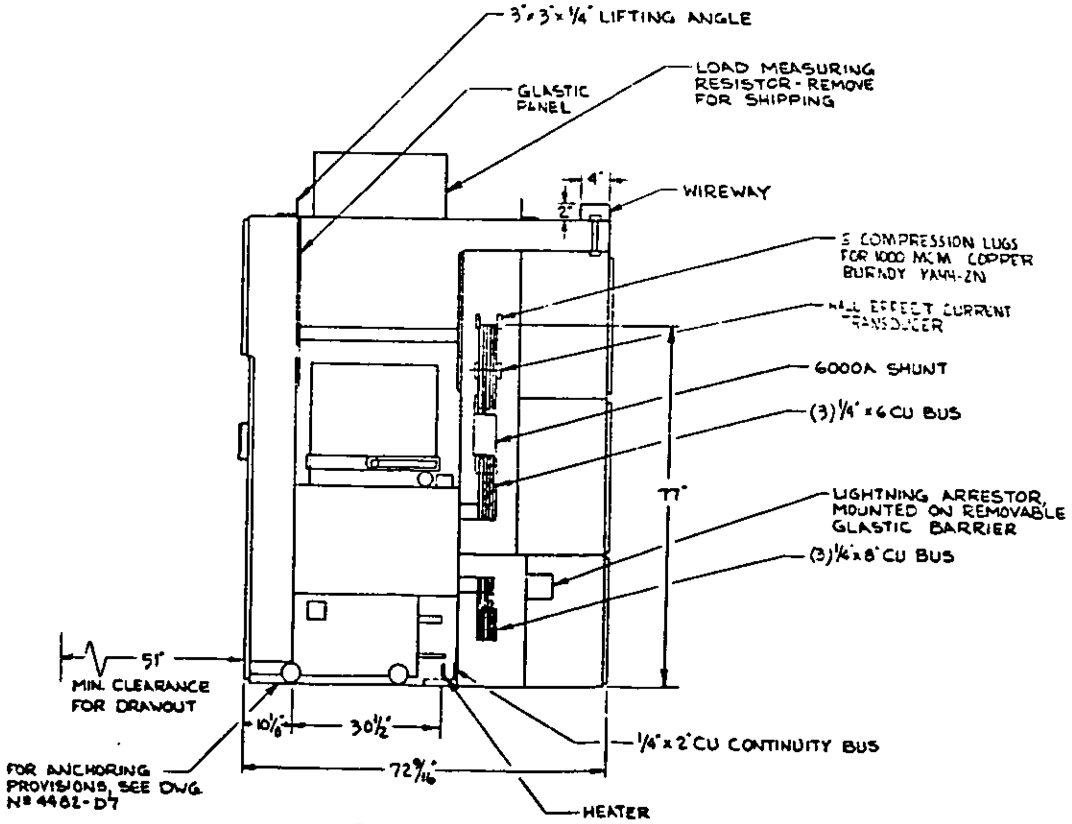
REV.



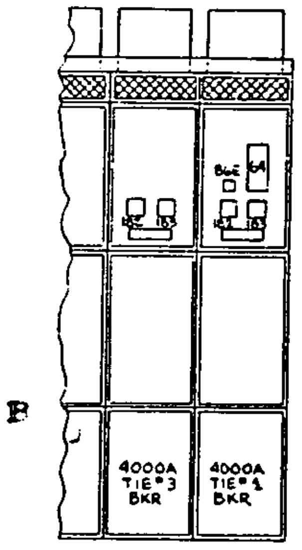
PLAN VIEW



FRONT VIEW



SECTION VIEW



REAR VIEW

FOR COMPLETE REAR VIEW SEE DWG NO. 4482-C116

FINISH-LIGHT GRAY NO. 61 ANSI Z 55.1
MINIMUM OF 2 MILS THK.

WEIGHT-
SWITCHGEAR- 4,800 lbs.
BREAKERS (EA)- 650 lbs.
TOTAL 8,050 lbs.

LEGEND-
172CS - BKR CONTROL SWITCH
W - WHITE LIGHT
AM - AMMETER
G - GREEN LIGHT
R - RED LIGHT
64 - HIGH RESISTANCE GND RELAY
86E - LOCKOUT RELAY
143 - REMOTE/LOCAL SWITCH
150 - RATE OF RISE RELAY
182 - CURRENT LOAD MEASURING RELAY
183 - VOLTAGE LOAD MEASURING RELAY
HA - HEATER AMMETER

MAY 25 1990

MICRO FILMED
C 1

REV. 1

PAB
5-18-88
NTS

CONTROLLED POWER CORP
MASSILLON, OHIO

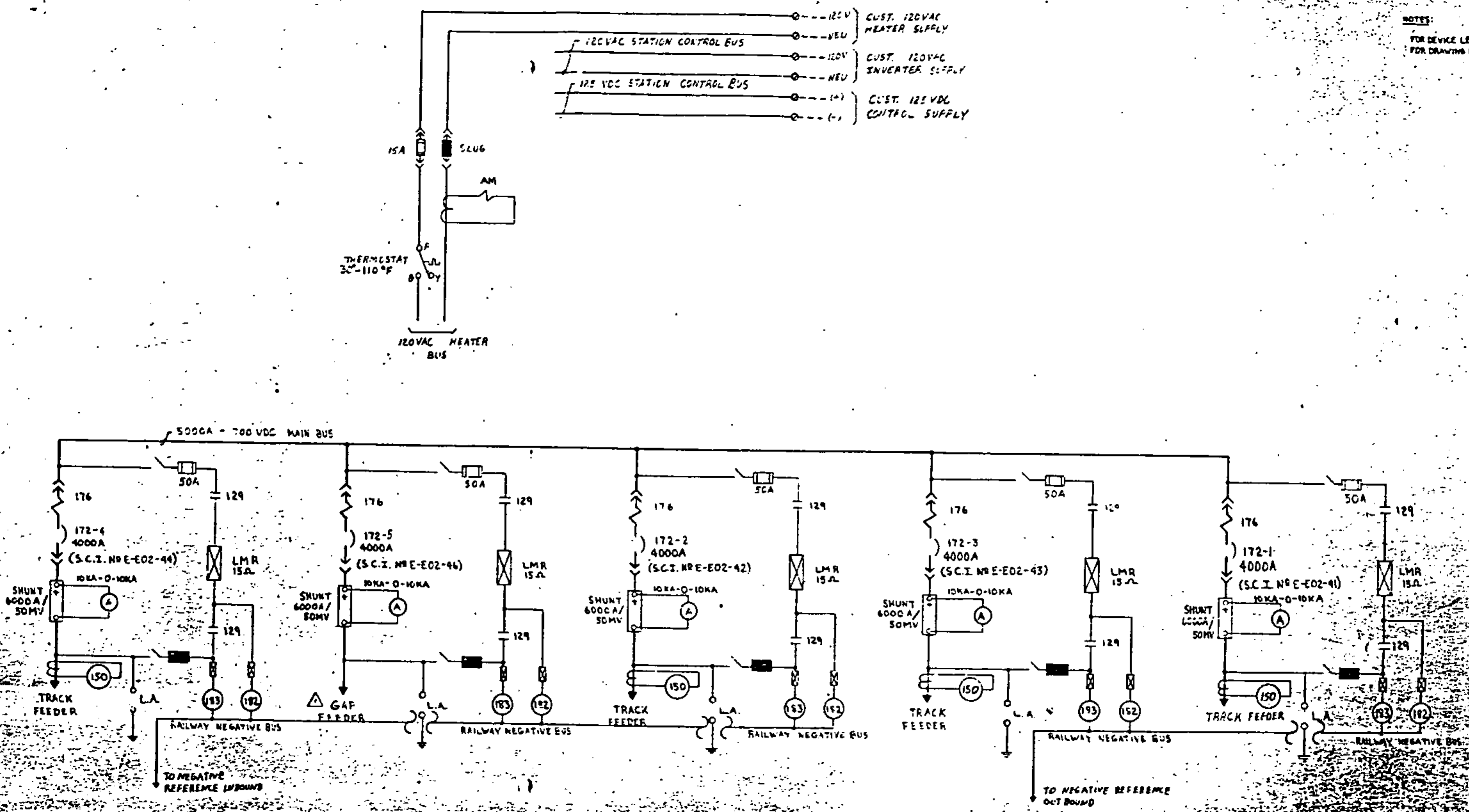
WMATA / SS-9
CONTRACT # 121049
KINGSTON CONTRACTORS

ELEVATION OF
SUBSTATION EQUIPMENT SS-9
TIE BREAKER STATION
SHAW
D.C. SWITCHGEAR

4482-D19

SHEET 1 OF

D



NOTES:

FOR DEVICE LEGEND SEE 4482-A1
FOR DRAWING REFERENCE SHEET SEE 4482-B2.

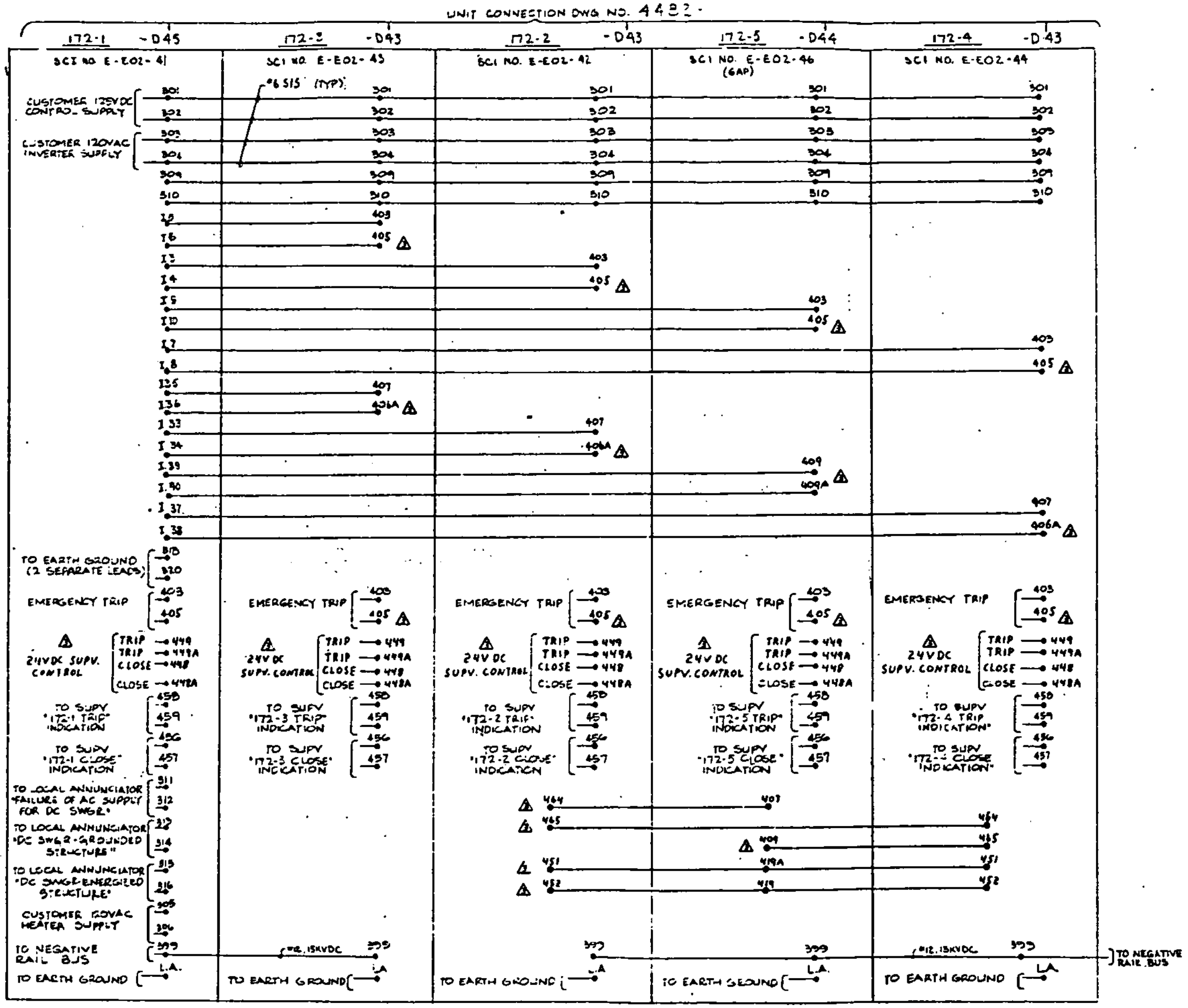
CONTROLLED POWER CORP.

JFR
5-18-88
AMRATG-169
CONTRACT
KINGSTON CONTRACTORS

POWER DIAGRAM
D.C. SWITCHGEAR
TIE BREAKER STATIONS
SHAW

4482-D

MAY 25 1990



NOTES:
ALL WIRE NO 14-SIS UNLESS NOTED

MAY 25 1990

1	JHS	10-21-88	ENG. REV.
2	WRG	1-23-89	REVISED WIRE SIZE TO MATCH CONTRACT DWG.
3	JHS	1-25-89	ENG. TEST REVS

A72 L-3

REV. 3

BJ

9-24-88

CONTROLLED POWER CORP.

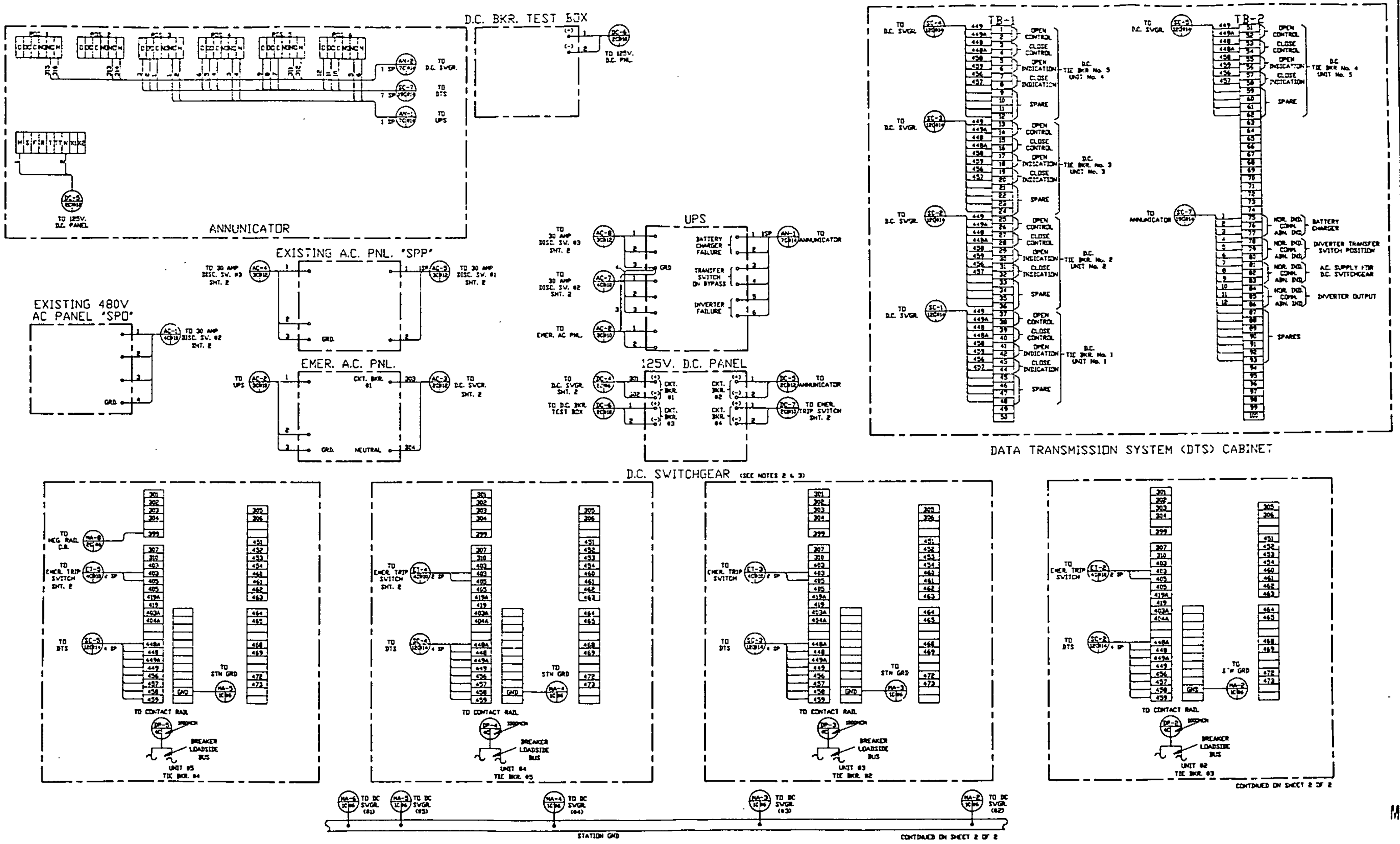
WMATA/SS-9

CONTRACT 1Z1049

KINGSTON CONTRACTORS

INTERCONNECTION DIAGRAM
DC SWITCHGEAR
TIE BREAKER STATIONS
SHAW

4482-D39



MAY 25 1990

REVISIONS		
NO.	BY	DATE
1	[illegible]	8/27/90

CUSTOMER APPROVAL REVISIONS

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-54, SS9-E-55, SS9-E-56, SS9-E-57, SS9-E-74.
2. ALL CUSTOMER CONNECTION TO D.C. SWITCHGEAR MADE ON FRONT METERING COMPARTMENT TERMINAL BLOCKS. (WITH EXCEPTION OF POWER CABLE CONNECTIONS)
3. SPARE TERMINALS IN DC SWITCHGEAR ARE SHOWN AS BLANKS.

MICROFILMED

DRAWN BY J.H.S.
DATE 4/10/89
SCALE NTS
CHK'D. BY
APP'D. BY

CONTROLLED POWER CORP.

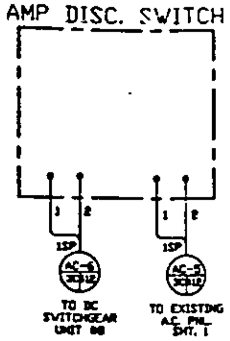
CUST. WMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE
EQUIPMENT INTERCONNECTION
SHAW
TIE BREAKER STATION

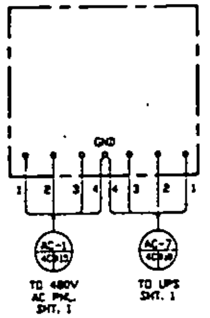
DWG. NO. 4482-D51
SHEET 1 OF 2

REV 1

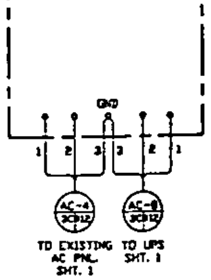
30 AMP DISC. SWITCH #1



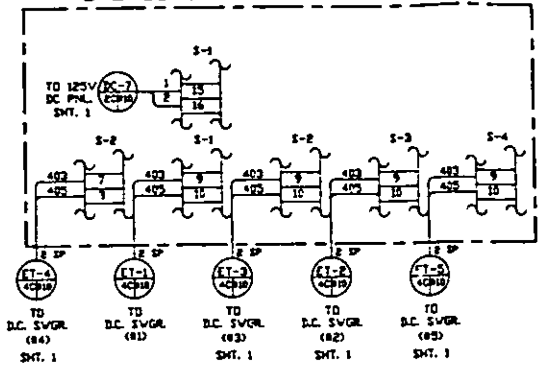
30 AMP DISC. SWITCH #2



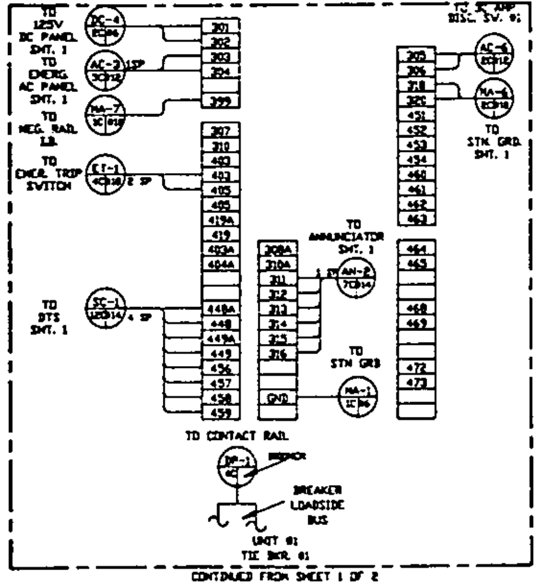
30 AMP DISC. SWITCH #3



EMERGENCY TRIP SWITCH PANEL



D.C. SWITCHGEAR (SEE NOTES 2 & 3)



MAY 2 5 1990

REVISIONS			
NO	BY	DATE	
1	[illegible]	8/27/90	CUSTOMER APPROVAL REVISIONS

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-54, SS9-E-55, SS9-E-56, SS9-E-57, SS9-E-74.
2. ALL CUSTOMER CONNECTION TO D.C. SWITCHGEAR MADE ON FRONT METERING COMPARTMENT TERMINAL BLOCKS. (WITH EXCEPTION OF POWER CABLE CONNECTIONS)
3. SPARE TERMINALS IN DC SWITCHGEAR ARE SHOWN AS BLANKS.

MICROFILMED

DRAWN BY J.H.S.
DATE 4/10/89
SCALE NTS
CHK'D. [illegible]
APP'D. [illegible]

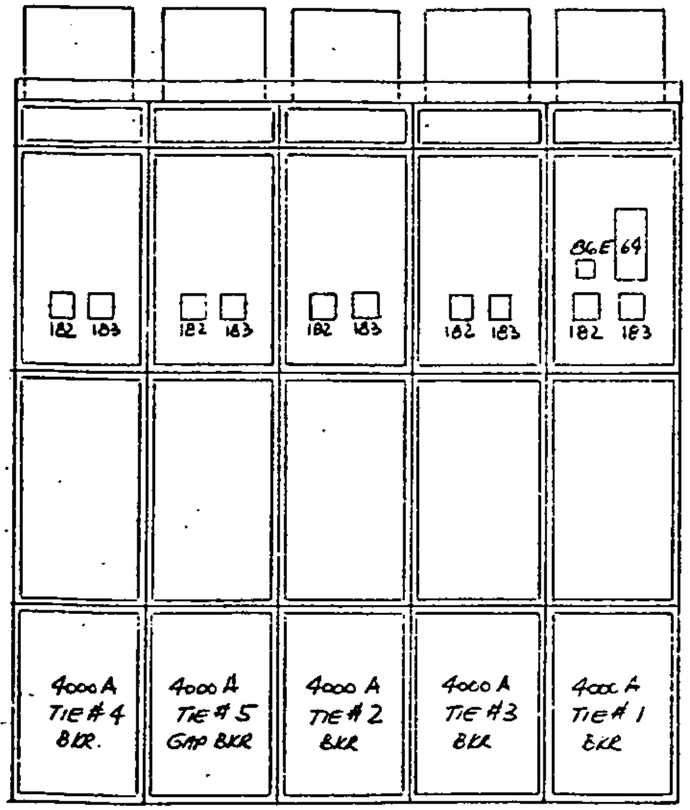
CONTROLLED POWER CORP.

CUST. VMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE
EQUIPMENT INTERCONNECTION
SHAW
TIE BREAKER STATION

DWG. NO. 4482-D51
SHEET 2 OF 2

REV 1



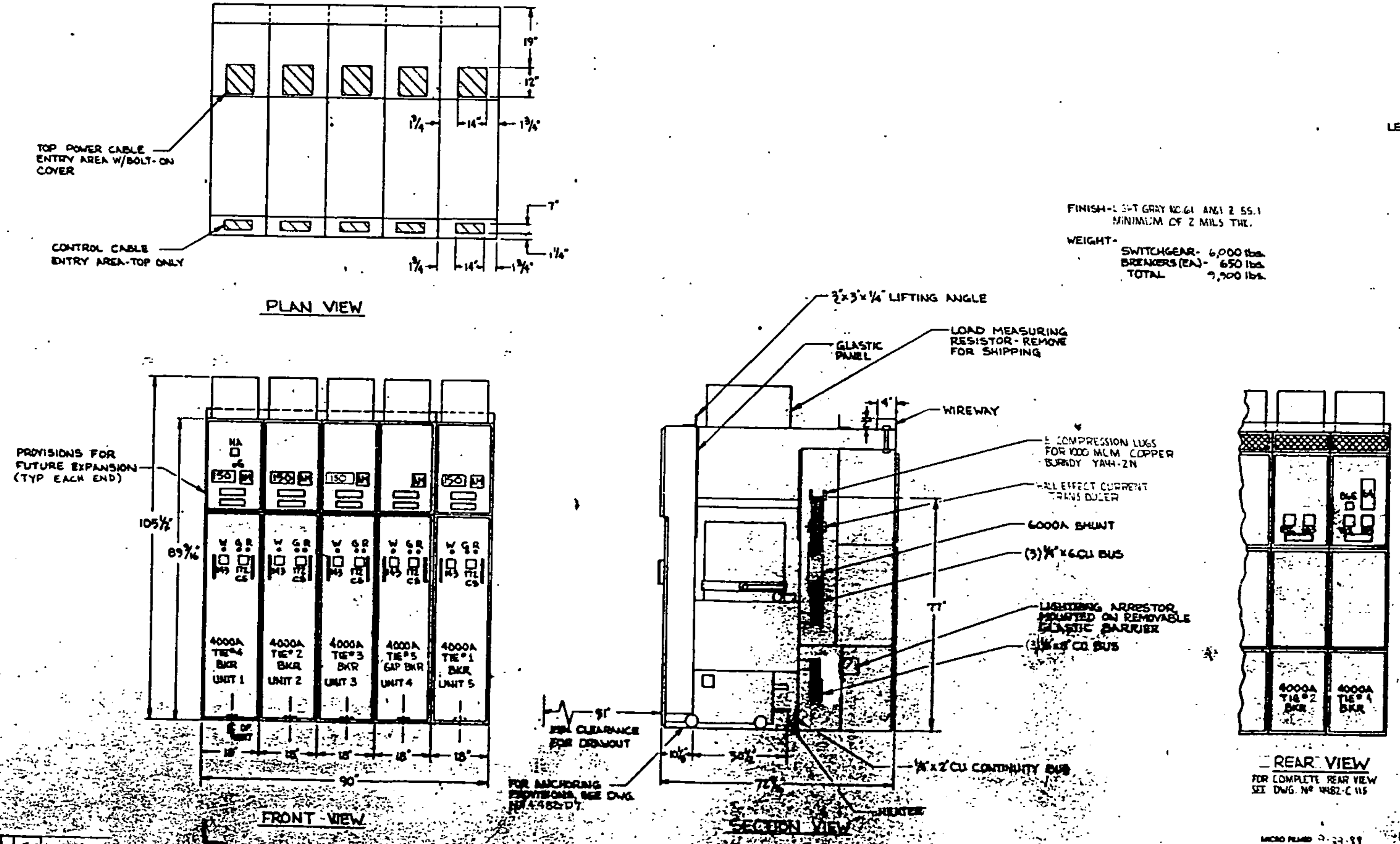
REAR VIEW

FOR ELEVATION & SECTION VIEW
SEE DWG. № 4482-D 19

MAY 2 5 1990

MICRO FILMED 9-30-88

DRAWN BY FBB	CONTROLLED POWER CORP 211 WETMORE AVE., S.E. • P. O. BOX [illegible] MASSILLON, OHIO [illegible]	TITLE REAR VIEW
DATE 9/20/88		TIE BREAKER STATION SHAW D.C. SWITCHGEAR
SCALE	CUSTOMER WMATA / SS-9	
CHK'D		DWG. NO. 4482-C 116
APP'D		REV.



FOR COMPLETE REAR VIEW SEE DWG. Nº 4482-C 115

FINISH- LIGHT GRAY NO.61 ANSI Z 55.1
MINIMUM OF 2 MILS THK.

WEIGHT-
SWITCHGEAR- 6,000 lbs.
BREAKERS (EA)- 650 lbs.
TOTAL 9,500 lbs.

LEGEND-
172CS - BKR CONTROL SWITCH
W - WHITE LIGHT
AM - AMMETER
G - GREEN LIGHT
R - RED LIGHT
64 - HIGH RESISTANCE GND RELAY
86E - LOCKOUT RELAY
143 - REMOTE/LOCAL SWITCH
150 - RATE OF RISE RELAY
162 - CURRENT LOAD MEASURING RELAY
163 - VOLTAGE LOAD MEASURING RELAY
HA - HEATER AMMETER

MAY 2 5 1990

MICRO FILMED 9-29-89

C

REV. 1

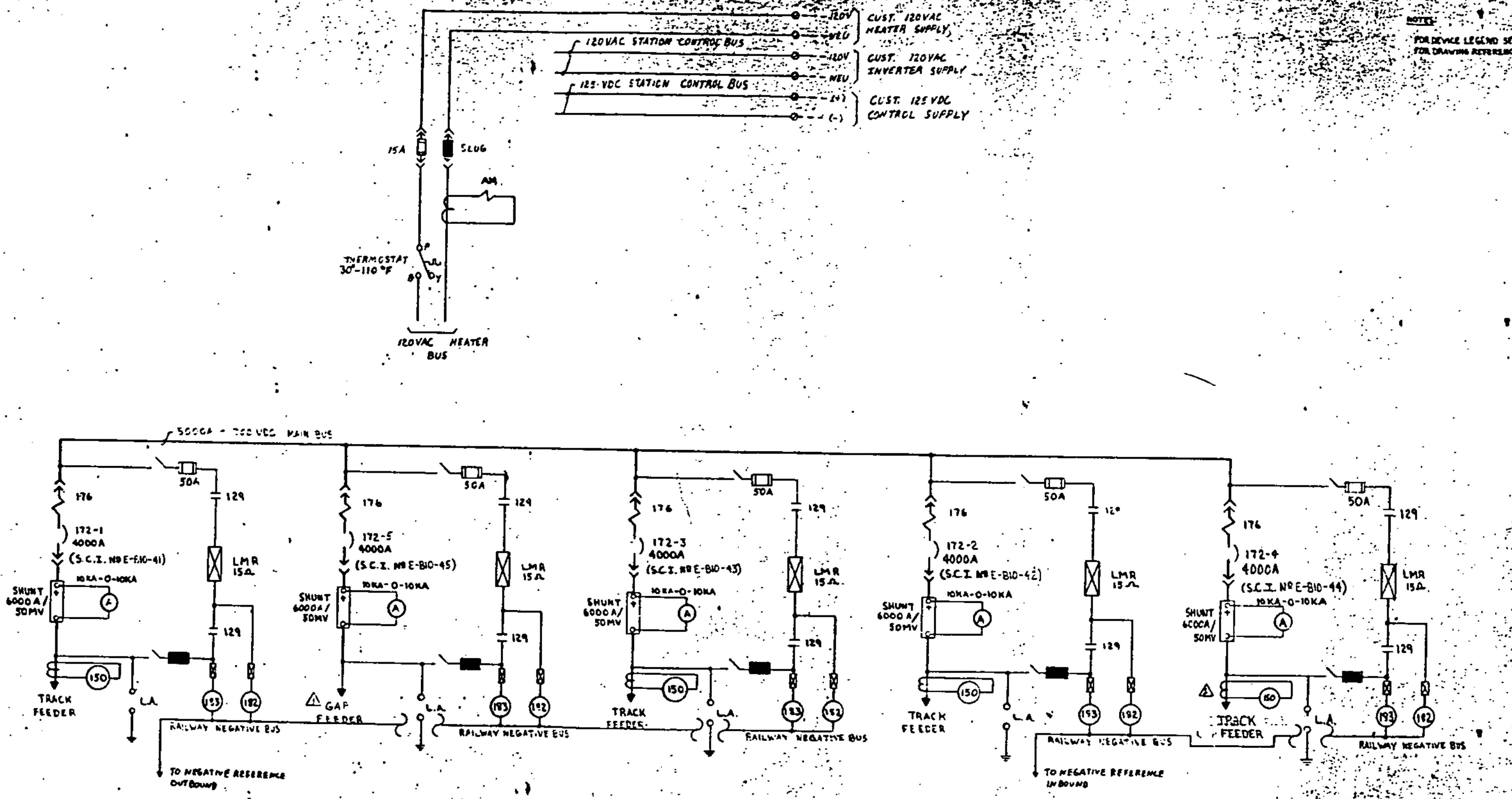
PAB
5-18-88
NTS

CONTROLLED POWER CORP

WMATA SS-9
CONTRACT # 1J1049-
KINGSTON CONTRACTORS

ELEVATION OF
SUBSTATION EQUIPMENT SS-9
TIE BREAKER STATION
WHEATON
D.C. SWITCHGEAR
4482-D18

D



NOTES:

FOR DEVICE LEGEND SEE 4482-A1
FOR DRAWING REFERENCE SHEET SEE 4482-B2

MAY 25 1990

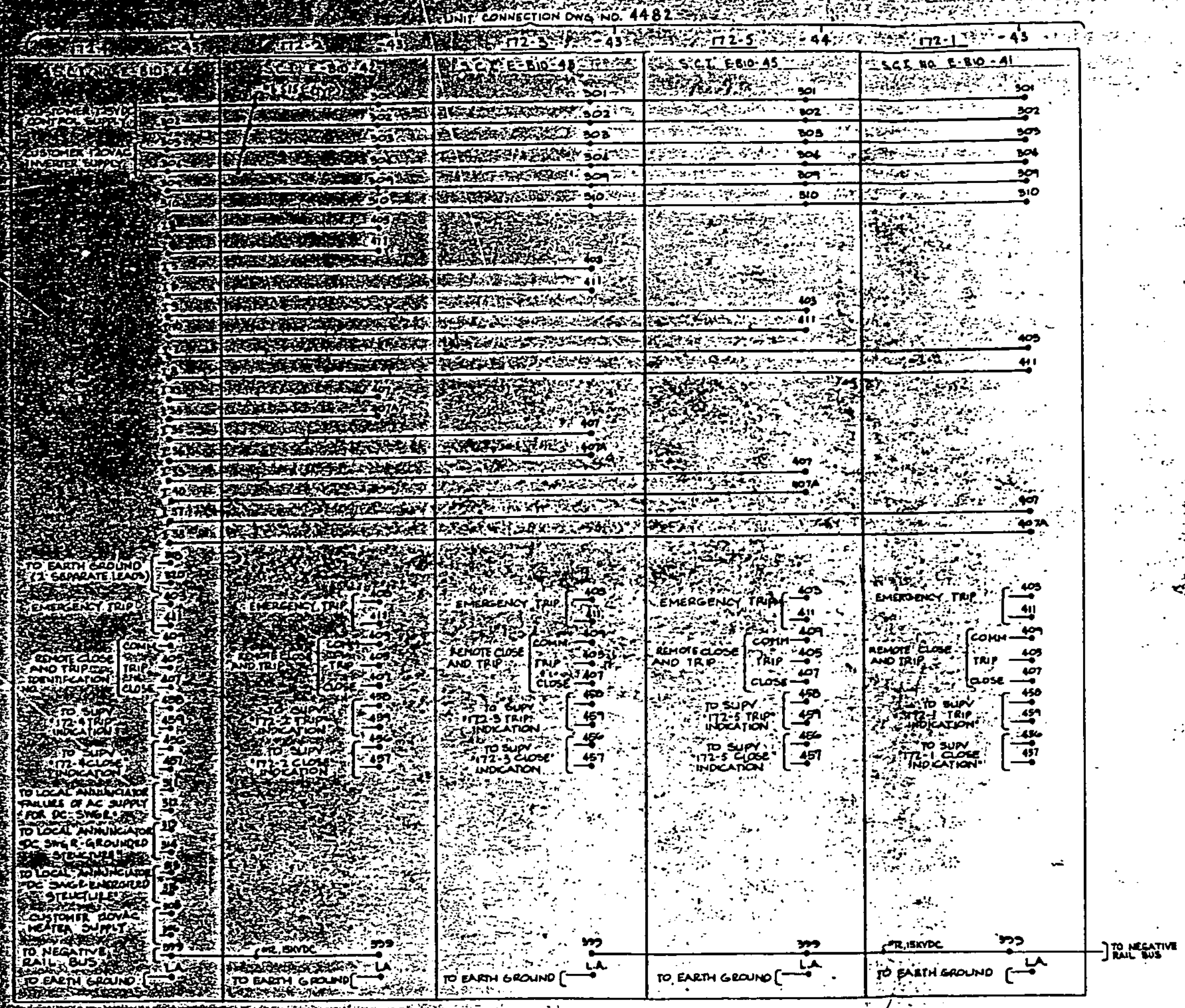
MICRO FILMED 10-4-93 C

JFR
5-21-88
[redacted]
WMATA 155-9
CONTRACT 9Z1049
KINGSTON CONTRACTORS

POWER DIAGRAM
D.C. SWITCHGEAR
TIE BREAKER STATIONS
WHEATON

4482-D28

REV. 1



NOTES:
ALL WIRE NO 14-SIS UNLESS NOTED

MAY 2 5 1990

REV. 2

MICRO FILMED

BJ

9-27-88

CONTROLLED POWER CORP

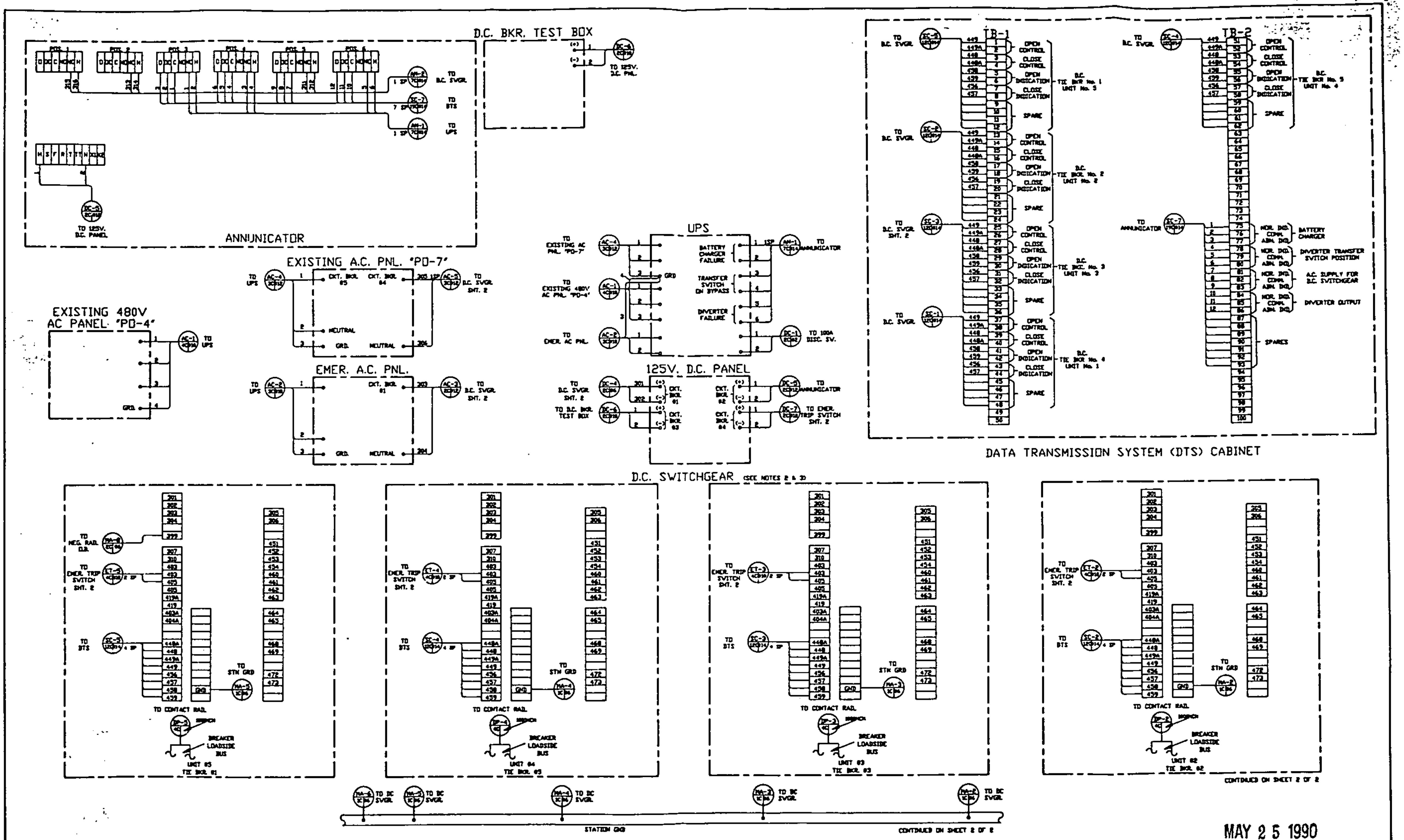
WMATA/SS-9

CONTRACT 121049

KINGSTON CONTRACTORS

INTERCONNECTION DIAGRAM
DC SWITCHGEAR
TIE BREAKER STATIONS
WHEATON

4482-D38



MAY 2 5 1990

MICROFILMED

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-37, SS9-E-38, SS9-E-39, SS9-E-40, SS9-E-73.
2. ALL CUSTOMER CONNECTION TO D.C. SWITCHGEAR MADE ON FRONT METERING COMPARTMENT TERMINAL BLOCKS. (WITH EXCEPTION OF POWER CABLE CONNECTIONS)
3. SPARE TERMINALS IN DC SWITCHGEAR ARE SHOWN AS BLANKS.

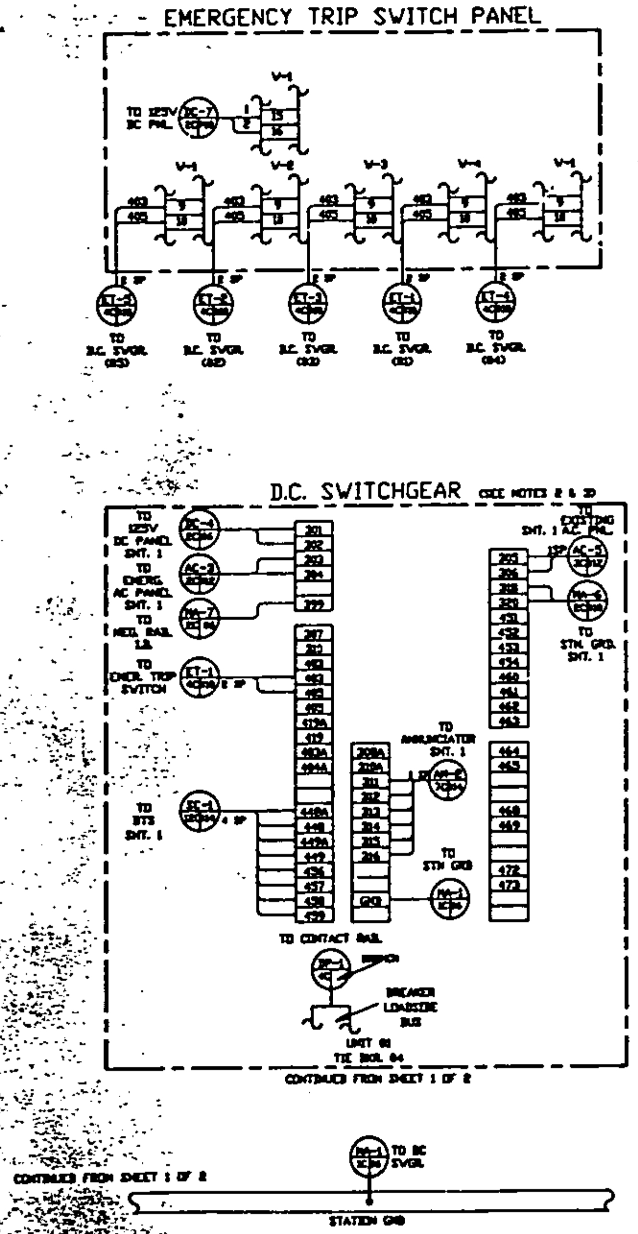
REVISIONS			
NO.	BY	DATE	
1	[illegible]	2/27/90	CUSTOMER REVISIONS APPROVAL

DRAWN BY J.H.S.
DATE 4/7/89
SCALE NTS
CHK'D. BOJ
APP'D. BOJ

[redacted]
CONTROLLED POWER CORP.
CUST. WMATA/SS-9
CONTRACT #1Z1049
KINGSTON CONTRACTORS

TITLE
EQUIPMENT INTERCONNECTION
WHEATON
TIE BREAKER STATION

DWG. NO. 4482-D50
SHEET 1 OF 2
REV 1



MAY 2 5 1990

REVISIONS

NO. BY DATE

1 [redacted] 5/7/90 CUSTOMER APPROVAL REVISIONS

NOTES:

1. DRAWING HAS BEEN CREATED IN CONJUNCTION WITH CONTRACT DRAWINGS SS9-E-37, SS9-E-38, SS9-E-39, SS9-E-46, SS9-E-73.
2. ALL CUSTOMER CONNECTION TO D.C. SWITCHGEAR MADE ON FRONT METERING COMPARTMENT TERMINAL BLOCKS. (WITH EXCEPTION OF POWER CABLE CONNECTIONS)
3. SPARE TERMINALS IN DC SWITCHGEAR ARE SHOWN AS BLANKS.

MICROFILMED

DRAWN BY J.H.S.

DATE 4/7/89

SCALE NTS

CHK'D. BY

APP'D. BY

[redacted]

CONTROLLED POWER CORP.

CUST. WMATA/SS-9

CONTRACT #1Z1049

KINGSTON CONTRACTORS

TITLE

EQUIPMENT INTERCONNECTION

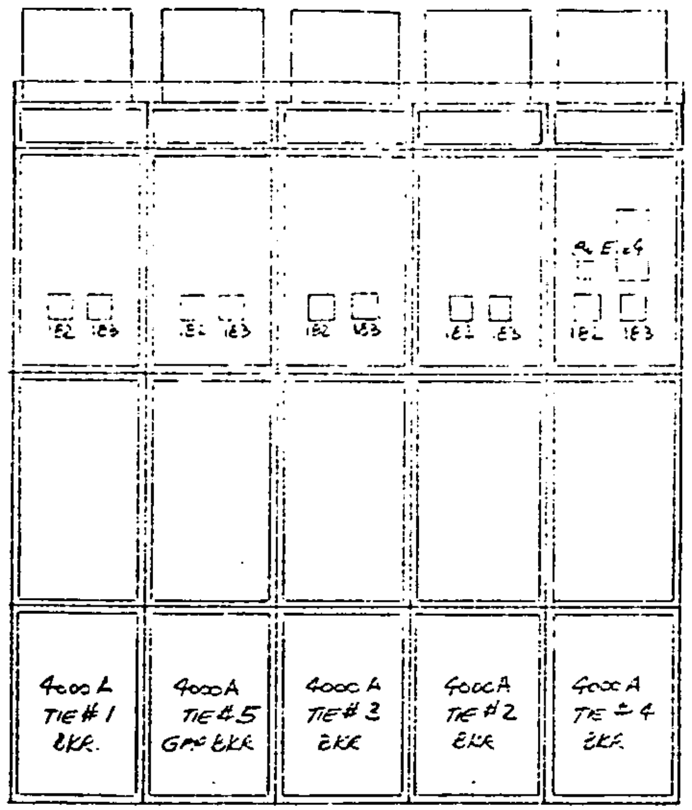
WHEATON

TIE BREAKER STATION

DWG. NO. 4482-D50

SHEET 2 OF 2

REV 1



REAR VIEW

FOR ELEVATION & SECTION VIEW
SEE DWG № 4482-D 18

MAY 25 1990

MICRO FILMED 9-30-88

DRAWN BY FBB	[redacted] CONTROLLED POWER CORP. 311 WETMORE AVE. S.E. • P. O. BOX [illegible] MASSILLON, OHIO [illegible]	TITLE REAR VIEW
DATE 9/20/88		TIE BREAKER STATION WHEATON D.C. SWITCHGEAR
SCALE	CUSTOMER WMATA / SS-9	
CHK'D		DWG. NO. 4482-C15
APP'D		

RENEWAL PARTS
800 VOLT DC METAL ENCLOSED SWITCHGEAR

for

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

Lansdowne Way Substation
Windham Lane Substation
Mount Vernon Square Substation
U Street Substation

WMATA Contract No. 1Z1049
SSE-9

Renewal Parts Manuals

Description	Mfr.	Publication
Indicating Light	G.E.	GEF-4326

Supersedes [illegible]

RENEWAL PARTS

Type ET-16 Indicating Lamps

Ordering Instructions

1. **Always specify the complete nameplate data of the equipment.**
2. Specify the quantity, catalog number (if listed), reference numbr (if listed), description, and this bulletin number.
3. For prices, refer to the nearest office of the General Electric Company.

TABLE 1
INDICATING LAMP, COMPLETE ASSEMBLY
(REFERENCE A)

Rating, Volts	Catalog Number
24	721-116B6708G1
48	721-116B6708G2
70	721-116B6708G7
120	721-116B6708G5
125	721-116B6708G3
130	721-116B6708G8
240	721-116B6708G6
250	721-116B6708G4

TABLE 2
COLOR CAPS
(REFERENCE B)

Catalog No.	Color
721-208A3768P1	Clear†
721-208A3768P2	Red††
721-208A3768P3	Green††
721-208A3768P4	Yellow††
721-208A3768P5	White††
721-208A3768P6	Blue†
721-208A3768P7	Amber†
721-208A3768P8	Green†
721-208A3768P9	Red†

† transparent †† translucent

TABLE 3
LAMP BULB
(REFERENCE C)

Catalog No.	Volts
721-1819	Δ 24
721-1835	Δ All Other

Δ With proper resistor

TABLE 4
RESISTOR
(REFERENCE D)

Rating, Volts	Catalog No.	Ohms, Total
24	721-165A7844P1	10
48	721-165A7844P2	200
70	721-165A7844P7	750
120	721-165A7844P5	1900
125	721-165A7844P3	2500
130	721-165A7844P8	2300
240	721-165A7844P6	4800
250	721-165A7844P4	5100

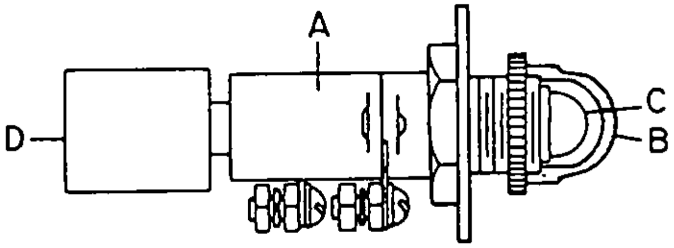


Fig. 1. Type ET-16 indicating lamps

Data is subject to change without notice.

GENERAL ELECTRIC COMPANY • METER AND CONTROL BUSINESS DEPT. • MALVERN, PA 19355

1-87 (3000)

GENERAL ELECTRIC

DRAWING LIST FOR
800 VOLT DC METAL ENCLOSED SWITCHGEAR

Bill of Material - Tab 1

Drawings Common to All Substations - Tab 2

DRAWING NO.	DESCRIPTION
4482-A1	Device Legend
4482-A2	Drawing Reference List
4482-D3	Cathode Breaker Elementary
4482-D4	Track Feeder Breaker Elementary
4482-D5	Gap & Storage Track Feeder Elementary
4482-D6	Common Circuits Elementary
4482-D7	Anchoring Detail
4482-D41	Wiring - Cathode w/ Current Transducer
4482-D42	Wiring - Cathode w/ Current, Voltage and Watt Transducer
4482-D43	Wiring - 4000A Track Feeder
4482-D44	Wiring - Gap of Storage Track Feeder
4482-D45	Wiring - Track Feeder w/ Aux. Circuits
4482-D46	Wiring - 6000A Track Feeder

Drawings for Particular Stations:

Windham Lane Substation - Tab 3

DRAWING NO.	DESCRIPTION
4482-D11	Elevation and Section Views
4482-D21	Power Diagram
4482-D31	Unit Interconnections
4482-D165	Substation Equipment Interconnections
482-C108	Rear View

Lansdowne Way Substation - Tab 4

DRAWING NO.	DESCRIPTION
4482-D12	Elevation and Section Views
4482-D22	Power Diagram
4482-D32	Unit Interconnections
4482-D164	Substation Equipment Interconnections
4482-C109	Rear View

U-Street Substation - Tab 5

DRAWING NO.	DESCRIPTION
4482-D13	Elevation and Section Views
4482-D23	Power Diagram
4482-D33	Unit Interconnections
4482-D167	Substation Equipment Interconnections
4482-C110	Rear View

Mount Vernon Square Substation- Tab 6

DRAWING NO.	DESCRIPTION
4482-D14	Elevation and Section Views
4482-D24	Power Diagram
4482-D34	Unit Interconnections
4482-D166	Substation Equipment Interconnections
4482-C111	Rear View

Mount Vernon Square Tie Breaker Station - Tab 7

DRAWING NO.	DESCRIPTION
4482-D15	Elevation and Section Views
4482-D25	Power Diagram
4482-D35	Unit Interconnections
4482-D49	Substation Equipment Interconnections
4482-C112	Rear View

Noyes Lane Tie Breaker Station - Tab 8

DRAWING NO.	DESCRIPTION
4482-D16	Elevation and Section Views
4482-D26	Power Diagram
4482-D36	Unit Interconnections
4482-D47	Substation Equipment Interconnections
4482-C113	Rear View

Hildarose Drive Tie Breaker Station - Tab 9

DRAWING NO.	DESCRIPTION
4482-D17	Elevation and Section Views
4482-D27	Power Diagram
4482-D37	Unit Interconnections
4482-D48	Substation Equipment Interconnections
4482-C114	Rear View

Shaw Tie Breaker Station - Tab 10

DRAWING NO.	DESCRIPTION
4482-D19	Elevation and Section Views
4482-D29	Power Diagram
4482-D39	Unit Interconnections
4482-D51	Substation Equipment Interconnections
4482-C116	Rear View

Wheaton Tie Breaker Station - Tab 11

DRAWING NO.	DESCRIPTION
4482-D18	Elevation and Section Views
4482-D28	Power Diagram
4482-D38	Unit Interconnections
4482-D50	Substation Equipment Interconnections
4482-C115	Rear View

CUSTOMER:WMATA/SS-9
CONTRACT 121049
KINGSTON CONTRACTORS

TITLE:750V DC METAL ENCLOSED
SWITCHGEAR.

WRITTEN BY:SIL DATE TYPED:05/26/88
CUSTOMER ORDER #22967PB
REVISION #: 4 REV. DATE:12/27/88

Tue Dec 27 1988

CPC BILL OF MATERIAL JOB # 4482

ITEM #	SYMBOL	P.O.# & ITEM	DESCRIPTION	MFR C'CODE	TYPE & CATALOG #	CLASS CPC I.D.#	QTY.	QT'Y. PER LOCATION UNIT/CUBICLE NO.													
								1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	72	4482-Y 1	CIRCUIT BREAKER, 800V DC, 6000 AMP, SINGLE POLE, 125V DC CONTROL, HIGH SPEED WITH: CONTROL SWITCH, LOCAL/REMOTE SWITCH, 12 STAGE AUXILIARY SWITCH, RED, WHITE & GREEN LIGHTS, 125V DC SHUNT TRIP, REVERSE CURRENT TRIP, OPERATION COUNTER	PAMCO 005	HSNP	BR BR-018	8	1	1	0	0	0	0	0	0	0	0	0	0	0	0
2	172	4482-Y 3	CIRCUIT BREAKER, 800V DC, 6000 AMP, SINGLE POLE, 125V DC CONTROL, HIGH SPEED WITH: CONTROL SWITCH, LOCAL/REMOTE SWITCH, 12 STAGE AUXILIARY SWITCH, RED, WHITE & GREEN LIGHTS, 125V DC SHUNT TRIP, BIDIRECTIONAL OVERCURRENT TRIP, OPERATION COUNTER AND U.V. RELEASE	PAMCO 005	HSNP	BR BR-019	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0
3	172	4482-Y 2	CIRCUIT BREAKER, 800V DC, 4000 AMP, SINGLE POLE, 125V DC CONTROL, HIGH SPEED WITH: CONTROL SWITCH, LOCAL/REMOTE SWITCH, 12 STAGE AUXILIARY SWITCH, RED, WHITE & GREEN LIGHTS, 125V DC SHUNT TRIP, BIDIRECTIONAL OVERCURRENT TRIP, OPERATION COUNTER AND U.V. RELEASE	PAMCO 005	HSNP	BR BR-020	38	0	0	1	1	1	0	0	0	0	0	0	0	0	0
4		4482-Y 7	CIRCUIT BREAKER CELL, 6000 AMP	CPC	HSNP	EN EN-135	12	1	1	0	0	0	1	0	0	0	0	0	0	0	0
5		4482-Y 8	CIRCUIT BREAKER CELL, 4000 AMP	CPC	HSNP	EN EN-136	38	0	0	1	1	1	0	0	0	0	0	0	0	0	0
6	SHUNT	4482-C 1	SHUNT, 8000 AMP, 50 MV, SWITCHBOARD TYPE	CROMPTON 053	886 886-92UU-UWEC	AC AC-0219	8	1	1	0	0	0	0	0	0	0	0	0	0	0	0
7	SHUNT	4482-C 2	SHUNT, 6000 AMP, 50 MV, SWITCHBOARD TYPE	CROMPTON 053	886 886-92UU-UPEC	AC AC-0220	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0

CUSTOMER:WMATA/SS-9 TITLE:750V DC METAL ENCLOSED SWITCHGEAR
CONTRACT 121049
KINGSTON CONTRACTORS

WRITTEN BY:SIL DATE TYPED:05/26/88
CUSTOMER ORDER #22967PB
REVISION #: 4 REV. DATE:12/27/88

Tue Dec 27 1988 CPC BILL OF MATERIAL JOB # 4482 PAGE 2

QT'Y. PER LOCATION

ITEM #	SYMBOL	P.O.# & ITEM	DESCRIPTION	MFR C'CODE	TYPE & CATALOG #	CLASS CPC I.D.#	QTY.	UNIT/CUBICLE NO.													
								1	2	3	4	5	6	7	8	9	10	11	12	13	14
8	AM	4482-AY 1	AMMETER, DC, SWITCHBOARD TYPE, 0-93.75MV MOVEMENT, 0-15KA SCALE	CROMPTON	700 077-0-15KA	AD AMDS-020	8	1	1	0	0	0	0	0	0	0	0	0	0	0	0
9	AM	4482-AY 2	AMMETER, DC, SWITCHBOARD TYPE, 125 MV-0-125MV MOVEMENT, 15KA-0-15KA SCALE	CROMPTON	700 077-15KA-0-15KA	AD AMDS-021	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0
10	AM	4482-AY 3	AMMETER, DC, SWITCHBOARD TYPE, 83.33-0-83.33MV MOVEMENT, 10KA-0-10KA SCALE	CROMPTON	700 077-10KA-0-10KA	AD AMDS-022	38	0	0	1	1	1	0	0	0	0	0	0	0	0	0
11	64	4482-A 3	RELAY, HIGH RESISTANCE GROUND AND POTENTIAL MONITORING	GEC 062	VAE21	RL RL-0259	9	0	0	0	0	1	0	0	0	0	0	0	0	0	0
12	86, 86S	4482-D 1	RELAY, LOCKOUT, HAND RESET, 4 DECK, 125V DC COIL, 8 N.O. & 8 N.C. CONTACTS	ES 062	LOR 7804D	RL RL-0060	9	0	0	0	0	1	0	0	0	0	0	0	0	0	0
13	27AC	4482-E 1	RELAY, UNDERVOLTAGE, 120V AC COIL, 2 FORM C CONTACTS	P & B 062	KRPA KRPA11AY120	RL RL-0260	9	0	0	0	0	1	0	0	0	0	0	0	0	0	0
14	64CX	4482-E 1	RELAY, UNDERVOLTAGE, 120V AC COIL, 2 FORM C CONTACTS	P & B 062	KRPA KRPA11AY120	RL RL-0261	9	0	0	0	0	1	0	0	0	0	0	0	0	0	0
15		4482-E 2	SOCKET, 8 PIN OCTAL	P & B 008	27E122	RL RL-0009	18	0	0	0	0	2	0	0	0	0	0	0	0	0	0
16	G	4482-F 1	INDICATING LIGHT, TYPE ET-16, RESISTOR TYPE, GREEN TRANSPARENT LENS, 125V DC (TRIP)	G.E. 056	ET-16 011686708G3G	LT LT-035	9	0	0	0	0	1	0	0	0	0	0	0	0	0	0
17	76	4482-A 1	RELAY, DC, OVERCURRENT, SHUNT OPERATED, 0-100 MV FULL SCALE DEFLECTION, SCALED 0-16KA, RELAY TO BE EQUIPPED WITH SEAL-IN AUXILIARY ELEMENT	GEC 062	DBA4	RL RL-0262	8	1	1	0	0	0	0	0	0	0	0	0	0	0	0

CUSTOMER:WMATA/SS-9
CONTRACT 121049
KINGSTON CONTRACTORS

TITLE:750V DC METAL ENCLOSED
SWITCHGEAR

WRITTEN BY:SIL DATE TYPED:05/26/88
CUSTOMER ORDER #22967PB
REVISION #: 4 REV. DATE:12/27/88

Tue Dec 27 1988 CPC BILL OF MATERIAL JOB # 4482 PAGE 3

ITEM #	SYMBOL	P.O.# & ITEM	DESCRIPTION	MFR C'CODE	TYPE & CATALOG #	CLASS CPC I.D.#	QTY.	QT'Y. PER LOCATION UNIT/CUBICLE NO.													
								1	2	3	4	5	6	7	8	9	10	11	12	13	14
18	CXD	4482-BJ 1	DC ISOLATION TRANSDUCER, OUTPUT 0-10V DC = 0-15KA DC, INPUT FROM 50 MV, 6000A SHUNT, 120V AC CONTROL POWER	096	SCI-COL 6271A	XD XD-195	8	1	1	0	0	0	0	0	0	0	0	0	0	0	0
19	VXD	4482-BJ 2	DC ISOLATION TRANSDUCER, OUTPUT 0-10V DC INPUT 0-5MA OUTPUT, 120V AC CONTROL POWER	096	SCI-COL 6271PA6-Z	XD XD-196	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0
20	RES	4482-BJ 4	DROPPING RESISTOR FOR DC VOLTAGE INPUT TO WXD, 3.85 MEGAOHM , 2 WATT METAL FILM TYPE IN METAL CAN	052	SCI-COL	XD XD-197	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0
21	WXD	4482-BJ 3	WATT TRANSDUCER, 0-5 MA VOLTAGE INPUT, 0-40 VOLT MAX CURRENT INPUT, OUTPUT 0-1 MA = 0-28 MW	096	SCI-COL 6268	XD XD-198	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0
22	TMWM	4482-AB 1	TELEMEGAWATTMETER-BINARY ANALOG TO RELAY CONVERTER INPUT 0-1 MA, OUTPUT 7 DIGIT BINARY FROM 7 N.O. REED RELAY CONTACTS, TEMP. RANGE 0 DEGREES C TO 50 DEGREES C, CONTACT RATING, 15VA, 1A MAX, EXTERNAL SAMPLE INPUT = 24V POWER SUPPLY 105-125V AC, ENCLO. SIZE K	OHI-SEMI 058	CAD CAD-1941	WD WHDM-033	4	0	1	0	0	0	0	0	0	0	0	0	0	0	1
23	129	4482-Q 1	CONTACTOR, 2 POLE, 780 VOLT, 50 AMP, 125V DC COIL 2 N.O. CONTACTS	WEST. 008	MME MME2050	AC AC-0221	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
24	182	4482-AZ 1	RELAY, RECLOSING, 4-1/2" SQUARE, SWITCHBOARD TYPE 125V AC AUXILIARY POWERED ELECTRONIC METER RELAY WITH ONE SETPOINT, ONE OUTPUT RELAY, LOW SET POINT UPSCALE ENERGIZED, RANGE 0143.75V DC TO 0-1.0 OHMS	062	LFE	BR BR-021	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
25	183	4482-AZ 2	RELAY, LOAD MEASURING, 4-1/2" SQUARE, SWITCHBOARD TYPE, 125V AC AUXILIARY POWERED ELECTRONIC METER RELAY, SCALED 0-800V DC, TWO SET POINTS AND 2 SPDT OUTPUT RELAYS, DOUBLE REVERSE SETPOINT ENERGIZED	062	LFE	BR BR-022	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0

CUSTOMER:WMATA/SS-9
CONTRACT 121049
KINGSTON CONTRACTORS

TITLE:750V DC METAL ENCLOSED
SWITCHGEAR

WRITTEN BY:SIL DATE TYPED:05/26/88
CUSTOMER ORDER #22967PB
REVISION #: 4 REV. DATE:12/27/88

Tue Dec 27 1988

CPC BILL OF MATERIAL JOB # 4482

PAGE 4

ITEM #	SYMBOL	P.O.# & ITEM	DESCRIPTION	MFR C'CODE	TYPE & CATALOG #	CLASS CPC I.D.#	QTY.	QT'Y. PER LOCATION UNIT/CUBICLE NO.													
								1	2	3	4	5	6	7	8	9	10	11	12	13	14
26		4482-AZ 3	HIGH VOLTAGE MULTIPLIER/LIMITER ASSEMBLY FOR 750V DC OPERATION OF 182 AND 183	 062	LFE	BR BR-023	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
27	201X	4482-U 1	PART NO. D2600/LES/20/CCT.A/FP22/110VDC RELAY LATCHING TYPE, 110V DC COIL SUICIDE CONTACTS IN SERIES W/BOTH COILS TWO "M" (MAKE ON ENERGIZE) AND 1 "B" (BREAK ON ENERGIZE) CONTACTS	C & S 062	02600	RL RL-0263	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
28	201X	4482-U 2	SOCKET W/FP22 FOULING PIN	C & S	D2600 D2600/FT/FP22	RL RL-0264	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
29	201C,T	4482-U 3	PART NO. D2600/2/FP24/24VDC AUXILIARY RELAY, 24V DC COIL, 2 N.O. CONTACTS	C & S 062	D2600	RL RL-0265	84	0	0	2	2	2	2	0	0	0	0	0	0	0	0
30	201C,T	4482-U 4	SOCKET WITH FP24 FOULING PIN	C & S	02600 D2600/FT/FP24	RL RL-0266	84	0	0	2	2	2	2	0	0	0	0	0	0	0	0
31	172Z	4482-V 1	PART NO. D2600/24/3X/FP6/110VDC AUXILIARY RELAY, 110V DC COIL WITH 3 N.C. AND 2 N.O. CONTACTS AND 1 N.O. EARLY MAKE CONTACT	C & S 062	D2600	RL RL-0267	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
32	172Z	4482-V 2	SOCKET WITH FP6 FOULING PIN	C & S	D2600 D2600/FT/FP6	RL RL-0268	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
33	186	4482-Z 1	TIMER ON DELAY, 120V AC COIL	ATC 062	319 319001601C	RL RL-0269	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
34	186	4482-Z 2	OCTAL SOCKET	ATC	 8256400	RL RL-0270	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0

CUSTOMER:WMATA/SS-9
CONTRACT 1Z1049
KINGSTON CONTRACTORS

TITLE:750V DC METAL ENCLOSED
SWITCHGEAR

WRITTEN BY:SIL DATE TYPED:05/26/88
CUSTOMER ORDER #22967PB
REVISION #: 4 REV. DATE:12/27/88

Tue Dec 27 1988 CPC BILL OF MATERIAL JOB # 4482 PAGE 5

ITEM #	SYMBOL	P.O.# & ITEM	DESCRIPTION	MFR C'CODE	TYPE & CATALOG #	CLASS CPC I.D.#	QTY.	QT'Y. PER LOCATION UNIT/CUBICLE NO.													
								1	2	3	4	5	6	7	8	9	10	11	12	13	14
35	186	4482-Z 3	TIMER SOCKET RETAINING CLIP	ATC	 03190250600	RL RL-0271	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
36	102	4482-Z 4	CAM TIMER, REPEAT CYCLE, 120V AC MOTOR 15 SEC/REV, 4 REV/MINUTE, 6 SWITCHES, RING TERMINALS FOR INCOMING CONNECTIONS	ATC 062	324C 06A3ER1A01S	RL RL-0272	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
37	LMR	4482-AA 1	LOAD MEASURING RESISTOR, 15 OHM, GRID TYPE, RATED 50 AMPS AT 750 VDC DESIGNED FOR A CONTINUOUSLY REPEATING DUTY CYCLE OF 1 MIN. ON 30 MIN. OFF	GUYAN	 15H50A	BR BR-005	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
38	150	4482-W 1	RELAY, DC OVERCURRENT, HALL EFFECT SENSOR OPERATED 125V DC CONTROL POWER	BBC 062	76T 20602240	RL RL-0273	36	0	0	1	0	1	1	0	0	0	0	0	0	0	0
39	DCCT	4482-W 2,4	HALL EFFECT DC SENSOR, 4000 AMP WITH 610178 CABLE	BBC	4000-6 609544-K2	CT CT-123	32	0	0	1	0	1	0	0	0	0	0	0	0	0	0
40	DC CT	4482-W 3,4	HALL EFFECT DC SENSOR, 5000 AMP WITH 610178 CABLE	BBC	5000-8 608768-T5	CT CT-124	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0
42		4482-S 1	LUG, COMPRESSION, 2 HOLE PAD, COPPER, 1000 MCM	BURNDY 064	YA YA44-2N	LG LG-036	218	0	0	5	5	5	7	0	0	0	0	0	0	0	0
43	TERM.BK	4482-P 1	TERMINAL BLOCK, 12 POINT, WITH COVER AND MARKING STRIP	MARATHON	1500H 1512H	TB TB-041	A.R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44		4482-P 2	TERMINAL BLOCK, 8 POINT, WITH COVER AND MARKING STRIP	MARATHON	1500H 1508H	TB TB-029	A.R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45		4482-R 1	TERMINAL BOARD, 6 STUD	G.E. 015	EB-4 2860351G3	TB TB-031	50	1	1	1	1	1	1	0	0	0	0	0	0	0	0

CUSTOMER:WMATA/SS-9 TITLE:750V DC METAL ENCLOSED SWITCHGEAR. WRITTEN BY:SIL DATE TYPED:05/26/88
CONTRACT 121049 CUSTOMER ORDER #22967PB
KINGSTON CONTRACTORS REVISION #: 4 REV. DATE:12/27/88

Tue Dec 27 1988 CPC BILL OF MATERIAL JOB # 4482 PAGE 6

ITEM #	SYMBOL	P.O.# & ITEM	DESCRIPTION	MFR C'CODE	TYPE & CATALOG #	CLASS CPC I.D.#	QTY.	QT'Y. PER LOCATION													
								UNIT/CUBICLE NO.													
								1	2	3	4	5	6	7	8	9	10	11	12	13	14
46		4482-N 1	PULLOUT FUSE BLOCK, 2 POLE, 250V, 30 AMP	FPE 014	C30-2	FU FU-023	209	4	4	4	4	5	4	0	0	0	0	0	0	0	0
47	FUSE	4482-G 3	CONTROL FUSE, CLASS R, 30 AMP, 250 VOLT	GOULD 013	FT FT-30	FU FU-138	200	4	4	4	4	4	4	0	0	0	0	0	0	0	0
48	FUSE	4482-G 4	CONTROL FUSE, CLASS R, 15 AMP, 250 VOLT	GOULD 013	FT FT-15	FU FU-139	51	0	0	1	1	2	1	0	0	0	0	0	0	0	0
49	FUSE	4482-G 5	CONTROL FUSE, CLASS R, 10 AMP, 250 VOLT	GOULD 013	FT FT-10	FU FU-140	104	2	3	2	2	2	2	0	0	0	0	0	0	0	0
50	HTR	4482-J 1	STRIP HEATER, 120V AC, 125 WATT	CHR'LOX 066	PT PT-512	AC AC-0222	50	1	1	1	1	1	1	0	0	0	0	0	0	0	0
51	H.THERM	4482-K 1	THERMOSTAT, ADJUSTABLE, 22 AMP MAX RESISTIVE, SPST	DAYTON	DPST 2E206	AC AC-0019	9	0	0	0	0	1	0	0	0	0	0	0	0	0	0
52	HAM	4482-AZ	AMMETER, 0-15 AMP, 2-1/2" SQUARE (HEATER LOAD)	LFE 058	AM19390000	AP AMAP-075	9	0	0	0	0	1	0	0	0	0	0	0	0	0	0
53	IT	4482-AH 1	ISOLATION TRANSFORMER, 1:1 RATIO, 600V, 10KV BIL, 150 VA	ITI 058	465 465-120	CT CT-125	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
54		4482-X 1	PULLOUT FUSE BLOCK, 1000 VOLT DC, 63 AMP, 1 POLE	CARBONE 014	S120 E97041	FU FU-141	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0
55		4482-X 2	PULLOUT FUSE BLOCK, 1000 VOLT DC, 63 AMP, 2 POLE	CARBONE 014	S1120 L97070	FU FU-142	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0

CUSTOMER:WMATA/SS-9
CONTRACT 121049
KINGSTON CONTRACTORS

TITLE:750V DC METAL ENCLOSED
SWITCHGEAR

WRITTEN BY:SIL DATE TYPED:05/26/88
CUSTOMER ORDER #22967PB
REVISION #: 4 REV. DATE:12/27/88

Tue Dec 27 1988 CPC BILL OF MATERIAL JOB # 4482 PAGE 7

ITEM #	SYMBOL	P.O.# & ITEM	DESCRIPTION	MFR C'CODE	TYPE & CATALOG #	CLASS CPC I.D.#	QTY.	QT'Y. PER LOCATION UNIT/CUBICLE NO.													
								1	2	3	4	5	6	7	8	9	10	11	12	13	14
56	FUSE	4482-G 1	FUSE, 1000V DC, 20 AMP	GOULD 013	101 A100P20	FU FU-143	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0
57	FUSE	4482-G 2	FUSE, 1000V DC, 50 AMP	GOULD 013	101 A100P50	FU FU-144	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
58		4482-AR 1	#14 AWG, CONTROL WIRE, 600V, 90 DEGREE C, TYPE SIS MINIMUM	COMM. 027		WI WI-009	A.R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59		4482-AG 1	#6 AWG, CONTROL WIRE, 600V, 90 DEGREE C, TYPE SIS MINIMUM	COMM. 027		WI WI-041	A.R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60		4482-BB 1	#12 AWG, CONTROL WIRE, 1KVDC MIN.	COMM. 027		WI WI-036	A.R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61		4482-AX 1	#8 AWG, CONTROL WIRE, 1KVDC MIN.	COMM. 027		WI WI-037	A.R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62		4482-M 1-6	CLIP SLEEVE WIRE MARKERS, VARIOUS LETTERS AND NUMBERS	BRADY	SCN	AC AC-0204	A.R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63		4482-L 1	THERMAL SLEEVING, 5/8", 1200 DEGREE F.	COLEFLEX 040	C F240-5/8	AC AC-0223	A.R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64		4482-H 1	KNIFE SWITCH, 125V DC, SINGLE THROW, 30 AMP	FILNOR	A-1102	AC AC-0210	50	1	1	1	1	1	1	0	0	0	0	0	0	0	0
65	TOC	4482-BR 1&2	TRUCK OPERATED CELL SWITCH FOR GEC - HSNP BREAKER	CPC	3798-0391	BR BR-024	50	1	1	1	1	1	1	0	0	0	0	0	0	0	0

CUSTOMER:WMATA/SS-9
CONTRACT 121049
KINGSTON CONTRACTORS

TITLE:750V DC METAL ENCLOSED
SWITCHGEAR

WRITTEN BY:SIL DATE TYPED:05/26/88
CUSTOMER ORDER #22967PB
REVISION #: 4 REV. DATE:12/27/88

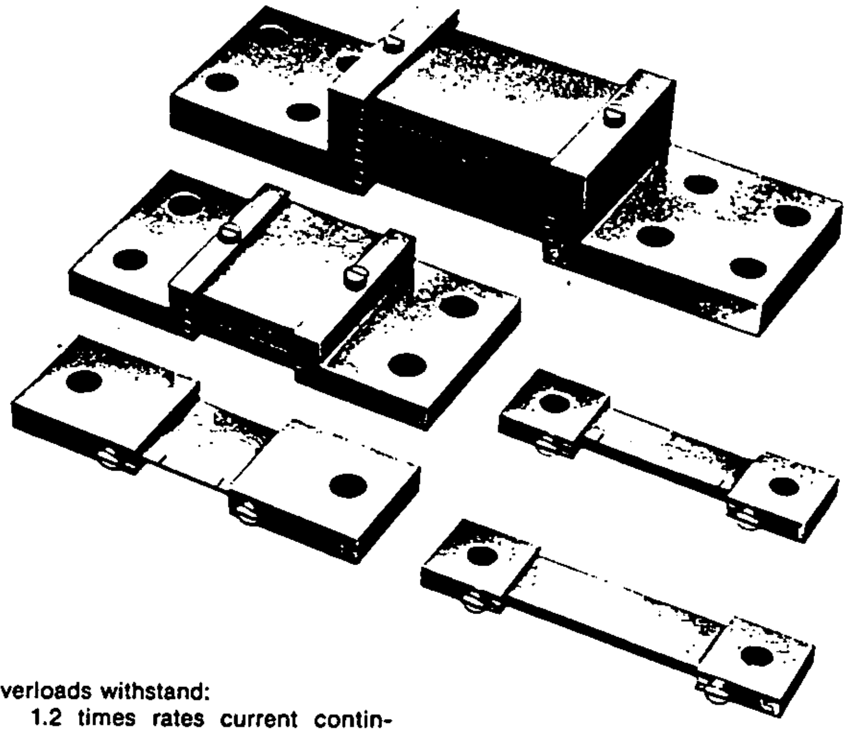
Tue Dec 27 1988 CPC BILL OF MATERIAL JOB # 4482 PAGE 8

								QT'Y. PER LOCATION													
								UNIT/CUBICLE NO.													
ITEM #	SYMBOL	P.O.# & ITEM	DESCRIPTION	MFR C'CODE	TYPE & CATALOG #	CLASS CPC I.D.#	QTY.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
66	CAP	4482-AM 1	SURGE CAPACITORS, 0-750 VOLT	G.E.	18L4NJ	LA LA-021	42	0	0	1	1	1	1	0	0	0	0	0	0	0	0
67	DIODE	4482-B 1	DIODE, 6 AMP, 400 VOLT	WEST.	R34 R3400406-8019	AC AC-0224	84	0	0	2	2	2	2	0	0	0	0	0	0	0	0
68		4482-AJ 1	STAND-OFF INSULATOR, 1-1/2 INCH HIGH FOR ITEM 66	GLASTIC	2015-3A	BU BU-134	168	0	0	4	4	4	4	0	0	0	0	0	0	0	0
69		4482-AD 1	KEY INTERLOCK	KIRK	FOE	AC AC-300	16	1	1	0	0	0	0	0	0	0	0	0	0	0	0
70		4482-AT 1	NEMA TYPE I ENCLOSURE WITH PANEL (FOR ITEM 22)	HOFFMAN	NEMA I A24N16A	EN EN-197	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Crompton Instruments

Edition 2

Shunts
880 Series



Designed and manufactured to give maximum reliability in arduous conditions, these heavy duty shunts provide an accurate d.c. millivolt signal suitable for ammeter indicators, overload protection and control devices. Standard outputs are 50mV and 100mV, other volt drop values are available.

- Accuracy class 0.25
- Ratings up to 10,000A.
- Riveted and soldered construction.
- Long term stability.
- In-line busbar mounting.
- Shock and vibration tested.

Construction

Highest quality materials, rugged design and advanced manufacturing techniques are used throughout. The substantial solid brass end blocks have conservatively rated contact surface area. For maximum long term stability and strength, manganin resistance elements are both riveted and hard soldered into slots in the end blocks.

Above 2000A, end blocks are multi-bladed. Model 886 accepts ¼ in. (6.35mm) busbars as standard and other sizes must be specified.

For current ratings of 30A and below, base mounted shunts should be used if the manganin element could be subject to damage due to flexing.

Specification

880 Series complies with BS89, IEC51 and AS1042 where appropriate.

Accuracy class: 0.25
Class 0.2 available on request.

Overloads withstand:
1.2 times rates current continuously.
5 second ratings:
40A-500A = 10 times
501A-2000A = 5 times
2001A-10,000A = 2 times rated current.

Temperature coefficient:
0.002% per °C overall.

Ambient temperature:
calibrated for 20°C, the working range is −20°C to +60°C.

Temperature rise:
corectly mounted in freely circulating air, temperature rise will not exceed 90°C.

Maximum load:
for maximum accuracy, load should not exceed 0.1% of the shunt current rating.

Shunt leads:
Supplied separately in pairs to ANSI C30.1. Standard length 5 ft. (1.52m) Resistance 0.065 ohms with hard soldered brass terminals and non-flammable drip proof insulation.

Installation

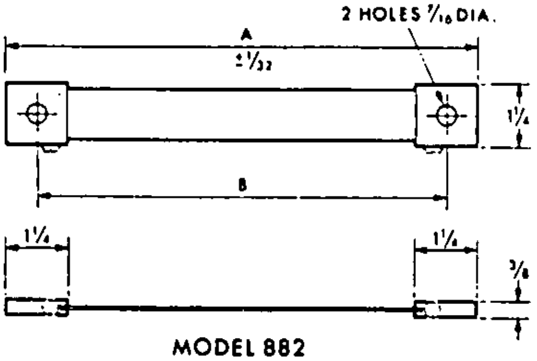
For maximum heat dissipation, mount shunts in the horizontal plane, with the blade faces vertical. Utilize the full end block contact surface area. Ample ventilation should be provided. Busbars should be adequately rated, clean and level, with a thin coat of silicone grease applied to the contact surface area. Use M10 (5/16 in.) fixing bolts with model 882 and M12 (½ in) for all other shunts. Use flat and tension washers under the nuts and tighten fully.

Insulated mounting blocks are available for models 882, 883 and 884. Dimensions on request.

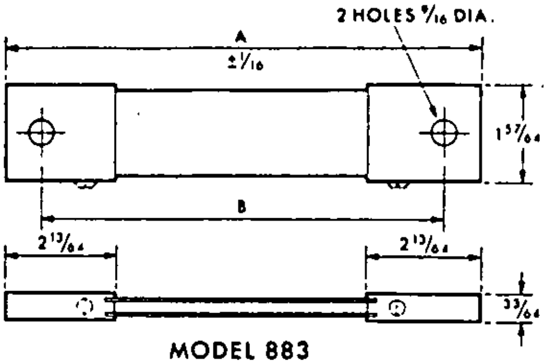
Safety at Work

Shunts are uninsulated and protection against accidental contact may be necessary.

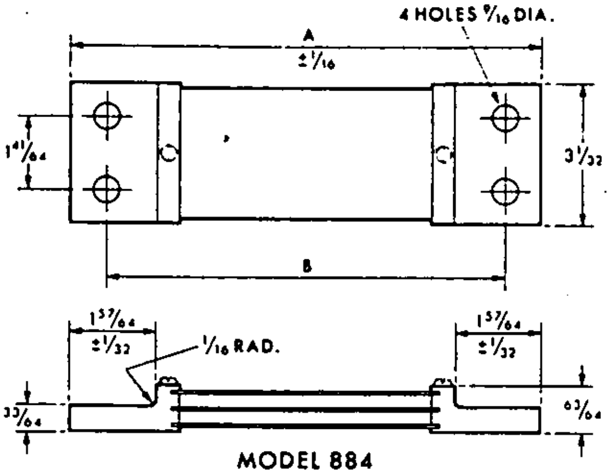
Dimensions in inches. Tolerances unless otherwise stated ±1/64



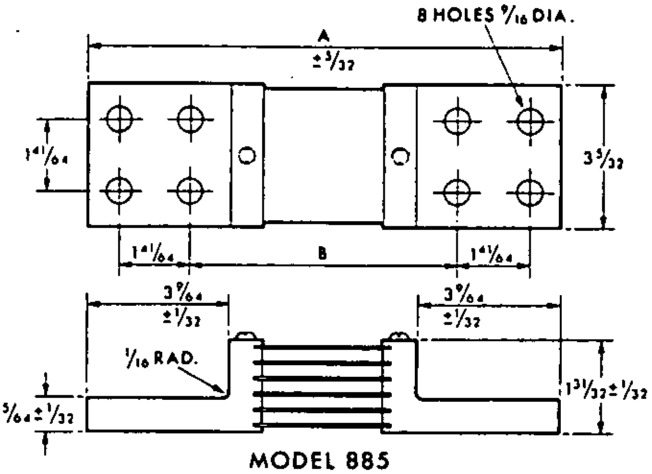
MODEL 882



MODEL 883

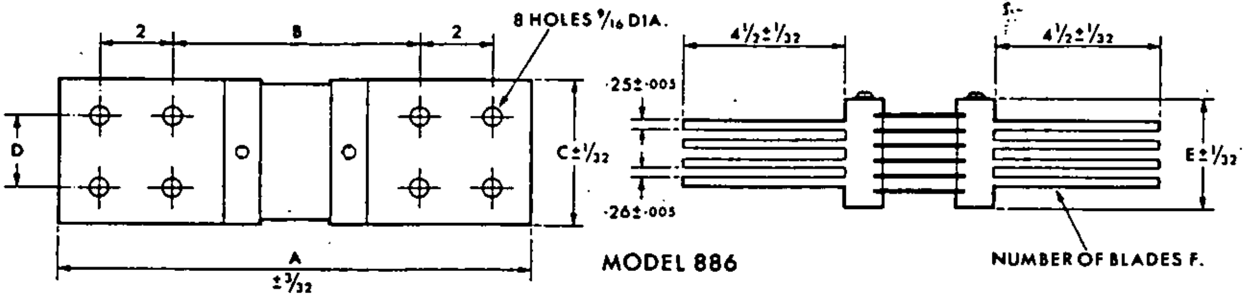


MODEL 884



MODEL 885

Current in Amps	MODEL	TYPE Nº.	50 mV		TYPE Nº.	100 mV	
			A	B		A	B
10 – 100 20 – 100	882	882 - 925	5 —	3 3/4 —	882 - 926	— 7 15/32	— 6 7/32
101 – 500	883	883 - 925	6 1/16	4 11/16	883 - 926	7 23/32	6 11/32
501 – 1000	884	884 - 925	6 9/16	5 1/16	884 - 926	8 3/8	6 7/8
1001 – 2000	885	885 - 925	9 7/8	5 3/8	885 - 926	12 1/16	7 9/16



MODEL 886

Current in Amps	TYPE Nº.	50 mV		TYPE Nº.	100 mV		C	D	E	F
		A	B		A	B				
2001 – 2500	886 - 925	12 5/8	6 5/8	886 - 926	14 1/4	8 1/4	4	2	1 1/2	2
2501 – 3000	886 - 925	12 5/8	6 5/8	886 - 926	14 1/4	8 1/4	4	2	2	3
3001 – 5000	886 - 925	12 5/8	6 5/8	886 - 926	14 1/4	8 1/4	4	2	3	4
5001 – 6000	886 - 925	12 5/8	6 5/8	886 - 926	14 1/4	8 1/4	4	2	4	5
6001 – 7000	886 - 925	12 5/8	6 5/8	886 - 926	14 1/4	8 1/4	5	2 1/2	4	5
7001 – 9000	886 - 925	12 5/8	6 5/8	886 - 926	14 1/4	8 1/4	5	2 1/2	4	6
9001 – 10000	886 - 925	12 5/8	6 5/8	886 - 926	14 1/4	8 1/4	5	2 1/2	5	7

All potential terminals for shunt leads are 10-32 UNF Slotted Pan head screws with washers.

CROMPTON INSTRUMENTS

MIDWEST: CROMPTON INSTRUMENTS INC. 2763 HIGGINS ROAD, ELK GROVE VILLAGE, ILLINOIS 60007
TELEPHONE: (312) 593-1107 TELEX: 28-0540
WEST COAST: CROMPTON INSTRUMENTS INC. 1562A PARKWAY LOOP, TUSTIN, CALIF. 92680
TELEPHONE: (714) 731-2333 TELEX: 69-2309
OTHER LOCATIONS IN: CANADA, AUSTRALIA, ENGLAND, SCOTLAND, HOLLAND, AND SINGAPORE

INSTALLATION INSTRUCTIONS

D.C. MOVING COIL AMMETERS AND VOLTMETERS

MOUNTING

Cut and drill panel as indicated in Fig.1. All drilling and wiring on the switchboard should be completed before mounting the instrument, and it is desirable to defer mounting as long as possible to reduce the risk of accidental damage to the front cover of the instrument while work is proceeding on the switchboard.

After mounting, correct any pointer deviation from zero by means of the zero adjuster.

WIRING

Connect the instrument as shown in the appropriate diagram overleaf. Terminal studs should be tightened sufficiently to ensure good contact but should not be over-tightened. The use of wrenches with over-long handles is, for this reason, deprecated.

The efficient magnetic screening of these instruments makes it unlikely that they could be affected by stray fields, but due precautions should be taken in keeping wires carrying heavy currents as far away from the instrument as is possible.

GROUNDING

On a metal panel which is itself grounded the instrument's fixing studs will securely ground its case provided care is taken to obtain a good metallic contact through any paint on the rear surface of the panel. On non-metallic panels, one of the fixing studs should be connected to ground.

AMMETERS

Direct-connected ammeters may be used on all loads up to and including 30 amps. For higher currents use an external shunt with a suitably-scaled 50mV ammeter indicator.

VOLTMETERS

Voltmeters may be direct-connected up to a maximum of 800 Volts, and must be protected by fuses.

MOVING COIL RECTIFIER INSTRUMENTS

For these A.C. instruments use the connection diagrams shown on page 16.

SHUNTS

A shunt dissipates the heat generated by the passage of current more by conduction and convection than by radiation. It is therefore necessary that the ends of shunts and of the conductors connected to them are of such cross-section and of such contact area as to prevent any undue temperature rise.

Where the shunt is built up of a number of strips of metal, cooling is best effected when the shunt is mounted horizontally with the strips in a vertical plane. If the shunt has to be mounted vertically with one terminal above the other, then the positive terminal should be the lower since, owing to the Peltier effect, the terminal at which the current enters the shunt will normally develop more heat than the other terminal.

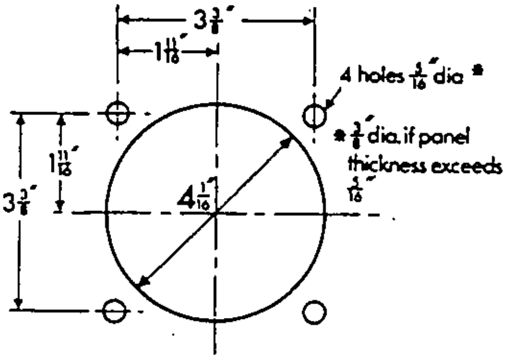


Fig.1. Panel drilling plan. For instrument dimensions see pages 11 and 12.

SHUNT LEADS

These are supplied with the instrument; standard length 5 ft. with resistance of 0.065 ± 0.01 ohm. They must not be cut and any excess length should be coiled and taped up close to the rear of the instrument. If the purchaser supplies shunt leads their resistance must agree with that quoted for the standard leads. Leads longer than 5 ft. can be supplied to order. If particularly long leads are unavoidable it may be necessary to use shunts and indicators of 100mV ratings; the maximum lead resistance is approximately 0.25 ohm for 50mV ratings and 1 ohm for 100mV ratings.

SHUNT LEAD COMPENSATING RESISTANCE

Alternatively, ammeter indicators can be supplied fitted with adjustable shunt lead compensating resistors to enable the indication to be adjusted to its true value on site. METHOD OF ADJUSTMENT. The indicator is marked with its mV rating and with its instrument plus leads resistance value. This is the total resistance of the indicator and shunt leads (with shunt disconnected) at which a true indication will be obtained. With the shunt disconnected, a resistance bridge should be connected across the shunt end of the leads; after setting the bridge to the resistance value marked on the indicator, the rheostat on the indicator should be adjusted until a zero deflection is obtained on the bridge galvanometer. Alternatively, if a resistance bridge is not available, a standard millivoltmeter should be connected across the shunt ends of the leads, with the shunt disconnected. With a low adjustable D.C. voltage source connected across the shunt ends of the leads, the voltage should be adjusted until the indication on the milliammeter agrees with the mV rating marked on the indicator. The rheostat on the indicator should then be adjusted to the point where the indicator reads full scale.

CLEANING

Before wiping or cleaning the outer surface of the front cover, all dust should be carefully brushed off to avoid any scratches on its surface.

Any superficial scratching which the plastic windows may sustain can be removed by careful use of a proprietary acrylic polishing agent. Care should be taken to avoid contacting plastic windows with spirit-based liquids as this would cause severe crazing.

COVER REMOVAL

Extreme precautions are taken in the factory to prevent the ingress of any dust into the interior of the instrument. Similar steps must be taken should it be necessary to remove the front cover of the instrument for any reason. The following procedure should be observed:-

1. On no account should the cover be removed in circumstances where ferrous particles however minute could conceivably enter the interior.
2. Every precaution should be taken to avoid the entry of dust. The operation should be carried out in reasonably dust-free conditions, and free from draughts or cross-currents of air.
3. When the cover is removed it should immediately be placed, inner surface downwards, on a clean sheet of paper, so that no dust can settle on its inner surface. Care should be taken not to rub or even touch the inner surface so as to avoid damage to the anti-static treatment applied at the factory.
4. Should it be necessary to leave the cover off the instrument for any length of time, the instrument should be screened from dust by being placed in a clean dust-free bag or container, preferably transparent. Care should be taken in doing this to avoid damaging the exposed pointer, dial, etc.
5. The cover must be replaced carefully, to ensure that the pin on the zero adjuster engages properly with its slot in the zero adjuster arm on the top cross-bar of the instrument mechanism.

REPAIRS

These instruments have 'Hi-Q' taut band suspended movements; see pages 5 & 6 for full details. They have no pivots, jewel bearings, spiral control springs, or pneumatic or magnetic damping arrangements to sustain damage or wear in use, and it is extremely unlikely that they will ever need servicing or repair. Should any instrument suffer such gross mechanical or electrical abuse as to affect its operation it should be returned to the manufacturer for attention. The assembly and adjustment of the mechanism can be carried out only on jigs specially designed for the purpose, and on no account should repairs be attempted by any other personnel, however skilled.

CONNECTION DIAGRAMS

REAR VIEW OF INSTRUMENT IS SHOWN

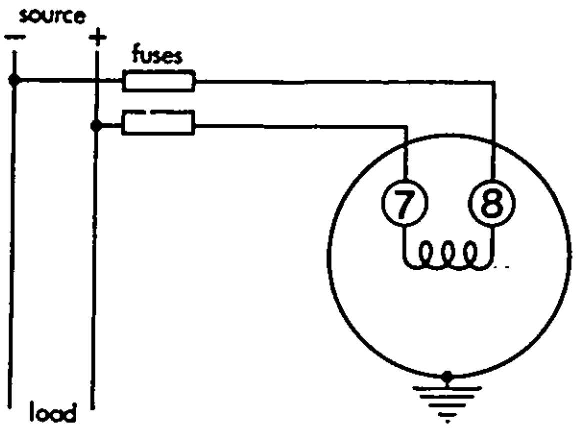


Fig.2. Direct-connected voltmeter

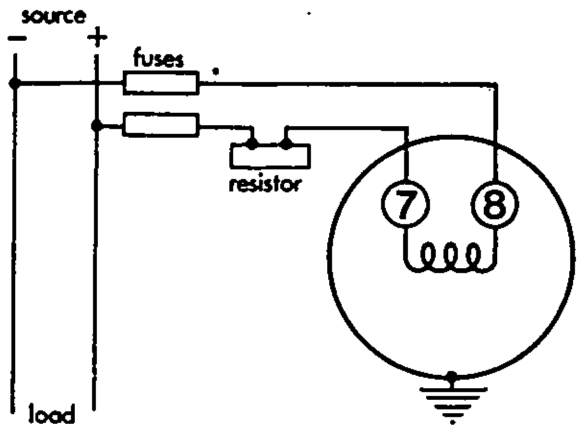


Fig.3. Voltmeter, over 750 volts, with external resistor.

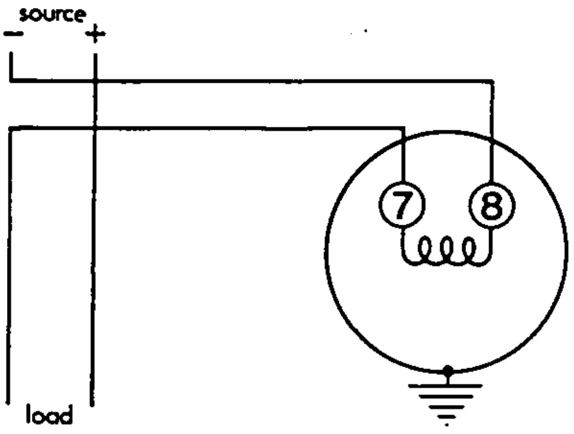


Fig.4. Self-contained ammeter.

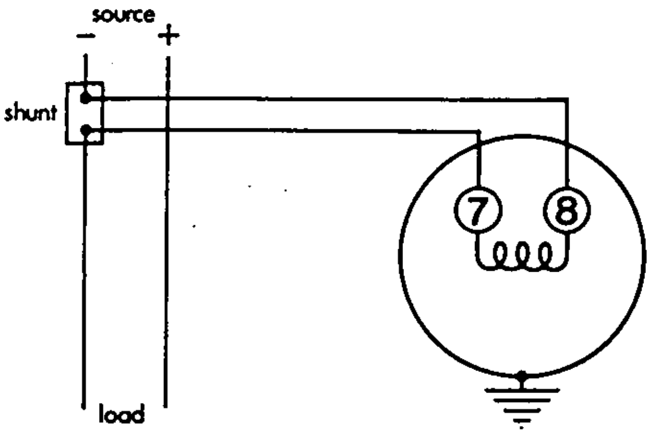


Fig.5. Ammeter indicator with external shunt.

CROMPTON INSTRUMENTS

MIDWEST: CROMPTON INSTRUMENTS INC. 2763 HIGGINS ROAD, ELK GROVE VILLAGE, ILLINOIS 60007
TELEPHONE: (312) 593-1107 TELEX: 28-0540
WEST COAST: CROMPTON INSTRUMENTS INC. 1562A PARKWAY LOOP, TUSTIN, CALIF. 92680
TELEPHONE: (714) 731-2333 TELEX: 69-2309
OTHER LOCATIONS IN: CANADA, AUSTRALIA, ENGLAND, SCOTLAND, HOLLAND, AND SINGAPORE

TECHNICAL DATA

D.C. MOVING COIL AMMETERS AND VOLTMETERS

GENERAL

These 4½ and 9in. square flange flush mounting switchboard instruments have a pointer deflection of 250 degrees and a scale length of 6.8 and 14in. respectively. They incorporate the most advanced form of Hi-Q oil-damped taut band suspension (Crompton patent) which completely eliminates pivots, jewel bearings, and spiral control springs. The built-in shock-absorbers, which are a prime feature of the Hi-Q system, give these instruments a phenomenal resistance to external shock and vibration and an unrivalled accuracy maintenance in service. For full details of the Hi-Q damping concept see pages 5 & 6, but attention is particularly called to the figures quoted overleaf for Damping Factor, Overshoot, and Response Time, all of which are substantially better than the requirements of ANSI C39.1 - 1981.

MAGNETIC SYSTEM

The self-shielding magnetic system comprises a yoke, outer pole piece, and inner core, all of soft iron, together with two magnets located in slots in the yoke. The magnets are of the anisotropic pattern; i.e. they are made from a special alloy the main constituents of which are iron, nickel, cobalt, and aluminum; in the casting process, the molten alloy is subjected to a strong magnetic field and, as it solidifies, the magnetic domains in the alloy remain aligned in the same direction.

MOVEMENT

The magnetic components are held rigidly between two heavy gauge aluminum plates. The moving coil is secured by brackets to the insulated moulded spindle is arranged so that one of its longer sides moves in the gap between the core and outer pole-piece of the magnet system.

e moving element is of unique design. A strip of metal ribbon soldered to an accurately centered locating plate is moulded into both ends of the spindle. To this spindle are attached the pointer, balance arm, two damping pads, and the moving coil. Both the ribbon and the metal locating plate are divided in the center, thus enabling the top and bottom sections of the ribbon to be used to conduct the current into and away from the moving coil.

This form of construction eliminates the mechanical joints used in the common form of taut band movement which has separate ribbons attached to each end of a metal staff, and thus adds considerably to the ruggedness of the movement.

The self-shielding magnetic system enables the instrument to be mounted at will on either ferrous or non-ferrous panels.

The dial plate has a platform scale on which the graduations are in the same plane as the tip of the pointer, thus eliminating parallax errors in reading.

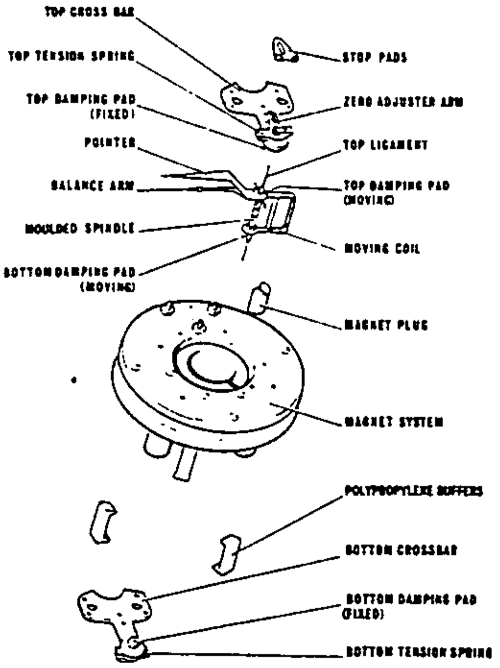


Fig. 1. Exploded view of movement.

CONSTRUCTION

The complete mechanism is mounted on a moulded baseplate into which captive 10-32 terminal studs, 1 3/16 in. long, are fitted. This assembly is housed in a heavy gauge pressed steel barrel with a square top flange which carries the integral ¼-28 fixing studs. Rubber washers on the mechanism fixing screws and polypropylene buffers on the periphery of the magnet system provide additional protection against external shock and vibration.

The front cover which carries the zero adjuster is secured to the flange of the barrel by screws in its four corners. It is therefore possible to remove the cover to obtain access to the dial etc. without having to take the instrument off the panel.

Where it is desirable to prevent zero adjustment by unauthorised persons, the cover can be supplied undrilled without a zero-adjuster button. Access to the zero-adjuster arm on the mechanism can then be obtained by removing the front cover from the instrument in situ.

A supplementary pre-set pointer can be fitted to the cover. Adjustable from the front, this can be used to mark a selected point on the scale.

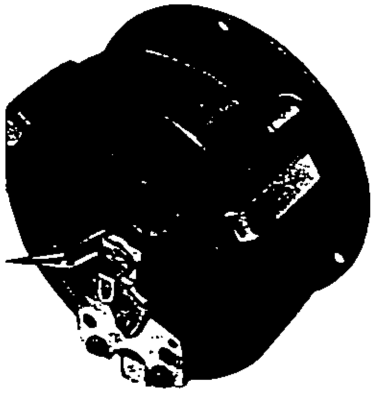


Fig. 2. The top aluminum fixing plate has been removed from this movement to show details of the magnet system.

SELF-CONTAINED RANGES

Microammeters.
200 microamps (min.) 500 microamps.
Milliammeters, Ammeters
Any desi.ed range from 1 mA up to 30 amps, in decimal multiples of the progression 1, 1.5, 2, 3, 4, 5, 6, 8.
Voltmeters
Any desired range from 50 mV up to 800 volts, in decimal multiples of the progression 1, 1.5, 2, 3, 4, 5, 6, 8.

APPROXIMATE TERMINAL RESISTANCES

Microammeters		Milliammeters	
Range	Resistance, ohms	Range	Resistance, ohms
		1	400
		5	20
200	1.200	10	5
500	200	20	2.5
		50	2

For ranges over 50 mA, and up to the maximum of 30 amps, the movement coil has an internal shunt.

Ammeter Indicators: for use with external shunt. Standard rating is 50 mV, 10 mA, at full-scale deflection, resistance 5 ohms. 100 mV or other ratings can be supplied to order. Voltmeters: standard resistance for ranges 1 volt and over is 1000 ohms per volt. Other sensitivities to order.

MOVEMENT TECHNICAL DATA

Weight of moving element, gm	0.8
Torque for full-scale deflection, gm/cm	0.2
Ampere-turns for full-scale deflection	0.4
Moving coil pole air gap, inches	0.094
Flux density, lines per sq. cm	1800

PERFORMANCE

When tested in accordance with ANSI C39.1 - 1981.

Accuracy Class .... 1 Percent

Overshoot: ....5% (C39.1 allows 10% max.)
Response Time: 1 second (C39.1 allows 2.5 seconds max.)
External Temperature Influence, with ±10°C change from 25°C:-
-Milliammeters 10 mA and over, and Ammeters: max. 1%
-Millivoltmeters, Voltmeters and Milliammeters below 10 mA: ....max. 0.5%
External Field Influence:...........0.5% max. with 0.5mT field
Self-heating Error:...Less than 0.3%
Dielectric Test: Live parts to case including zero adjuster and panel - 2600V. RMS for 1 minute.
Overload Capacity:-
-Ammeters: 1000% momentarily, 100% for 15 minutes, and 50% indefinitely.
-Voltmeters: 25% indefinitely.

RECTIFIER PATTERN, FOR USE ON A.C.

These instruments can be supplied fitted with full-wave rectifiers and calibrated for use on A.C. These instruments have high sensitivity and low power consumption, and are suitable for use on frequencies up to 10kHz.
Sensitivity: milliammeters, approx. 1 to 1.5V drop at FSD
voltmeters, 5 volts and over, 1000 ohms per volt.
Accuracy Class: 2.0
Self-contained Ranges:-
—Milliammeters: min. 1 mA, max. 200 mA.
—Ammeters, with internal C.T.: 0.5, 1, 2.5, 5, 10, 20, or 30A
—Voltmeters: min. 5 volts, max. 800 volts.
—Voltmeters with internal P.T.: 0.25, 0.5, 1, 1.5, or 2 volts
Preferred Scalings: decimal multiples of the progression 1, 1.5, 2, 3, 4, 5, 6, 8.

SHUNT LEADS

D.C. Ammeter Indicators when supplied with external shunts are provided with shunt leads 5 ft. long, having a resistance of 0.065 ± 0.01 ohm. These leads are to be considered as part of the indicator, the two being calibrated together. Longer leads can be supplied to order.

SHUNT LEAD COMPENSATING RESISTOR

Indicators can be supplied fitted with an adjustable shunt lead compensating resistor on the terminal baseplate. By this means, an installation having leads of non-standard resistance can be adjusted on site to give a true indication on the instrument of the current flowing in the circuit.

SPECIAL FEATURE AVAILABILITY

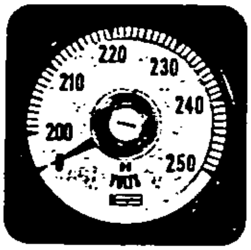


Fig. 3

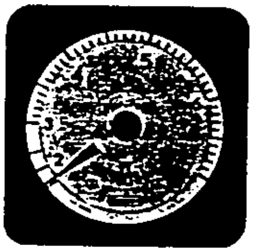


Fig. 4.

SUPPRESSED ZERO INSTRUMENTS

D.C. instruments can have mechanically-suppressed zeros, the maximum degree of suppression being 20% of full-scale value. •

EXPANDED SCALE D.C. VOLTMETER Fig. 3.

By the use of inbuilt zener diodes the lower 80% of the scale range can be compressed, without loss of the zero point, giving a scale shape as shown in Fig. 3. This f ure can be provided on any D.C. voltmeter from 0-3-7 v upwards but not on rectifier pattern A.C. instruments.

POT-LINE VOLTMETERS Fig. 4. (High-shock, 800 series)

Special voltmeters can be supplied for use in smelter plants to withstand conditions of high ambient temperature and strong magnetic fields. Other features include compressed lower scale and built-in continuous overload protection of ten times full-scale value.

OTHER MODIFICATIONS

The following are available to order:-
Center or offset zero.
Dials in colors other than white.
Colored lines or segments on scale.
Additional set of figures on one scale.
Additional scale on same (flat) dial.
Flat dial with finely-divided scale and knife-edged pointer.
Captions other than standard electrical unit designation.
Captions in languages other than English.
Customer's name or logo on dial.
Calibration in terms of non-electrical quantities, including applications where the required correspondence between scale intervals and deflection force is non-linear.
Non-reflecting finish on windows.
Heavily-damped movement.
Sealed panclimatic case. (4½in. size only, 800 series)

For installation instructions see pages 19 & 20.

GEC Measurements

Publication R-5443PB

THE GENERAL ELECTRIC COMPANY LIMITED . ST. LEONARDS WORKS . STAFFORD . U.K.

TYPE VAE21
FRAME LEAKAGE RELAY FOR HIGH RESISTANCE EARTH FAULTS

Issued June 1981

RELAY TYPE VAE21
FRAME LEAKAGE RELAY FOR HIGH RESISTANCE EARTH FAULTS

APPLICATION

Structures or frames, such as those surrounding rectifiers or rectifier supply busbars, can become accidentally 'live' due to faults. Such frames, nominally insulated from earth, can be bonded together and connected to earth by an earth bar. For such schemes, protection against earth faults has often been provided by the main system overcurrent relays, but measurement of current or voltage to earth can ensure faster, more sensitive protection.

A typical scheme for low resistance earth fault protection is described in Publication R-5252.

High resistance faults between frame and earth develop high voltages, which are dangerous to personnel and to equipment. Main system overcurrent relays would be insensitive to such faults, but the type VAE21 relay will detect high resistance faults; it has the following features:

* Suitable for protection of a.c. and d.c. systems
* Fast operation
* Continuously monitors the voltage between the protected structure and earth
* Continuously monitors the protective circuits
* Limits fault currents
* Initiates alarms
* Disconnects power sources from the fault

OPERATION

The relay is connected in two separate paths between the protected structure and earth, as shown in the simplified diagram, Figure 1.

Relay element 64X is a continuously energised voltage monitoring device. An a.c. supply is fed via a transformer to a bridge rectifier in the relay. The bridge rectifier output circulates via: normally closed (break) type contacts 64C-2 and 64C-1, the protected structure, relay coils 64C and 64X in series, and earth, back to the rectifier. This d.c. voltage energises relay 64X but is too low to operate relay 64C.

A short circuit between the protected structure and earth, separate from the relay paths, will short-circuit the relay coils. Relay 64X will be de-energised, operate its flag or target, and operate contacts for alarm initiation.

A break in the connections between the protected structure and earth, or an a.c. supply failure, will also de-energise relay 64X, causing contact operation for alarm indication, plus flag operation.

If the protected structure becomes accidentally live due to a fault, the voltage between the structure and earth will increase and operate relay 64C. This will open contacts 64C-1 and 64C-2 and operate other contacts to trip the power supply to the rectifier and to initiate alarms. The operation indicator flag will also operate. Circuit components limit fault currents to a safe value.

After a fault, the flag indicator and the hand reset contacts of the tripping relay must be reset. The isolating contacts in the supply to the incoming transformer must be operated by hand to interrupt the monitoring supply and allow the tripping relay contacts and operation indicator to be reset.

TECHNICAL DATA

VOLTAGE RATINGS

Auxiliary supply, monitoring voltage, a.c. input: 110/125V, 50Hz or 60Hz, or 230/250V, 50Hz or 60Hz.

The relay will withstand up to 1000 volts a.c. r.m.s. or 1000 volts d.c.

SETTINGS

Single, preset voltage at which monitoring relay 64X operates: 20V or 50V or 70V (d.c. or r.m.s. a.c. 50Hz or 60Hz).

RELAY BURDENS

Depends upon applied voltage, contacts etc., but typically is less than 10VA d.c. or a.c.

CONTACTS

Relay 64C is a VAA13 relay, and has up to 4 hand reset contacts: 64C-1 and 64C-2 are break (normally closed) contacts, plus one make and one break contact, and hand reset operation indicator.

Relay 64X is a VAA11 relay and has up to 4 self reset contacts, normally two make and two break type, and a self reset operation indicator.

OUTPUT CONTACT RATINGS

SYSTEM	MAKE AND CARRY CONTINUOUSLY	MAKE AND CARRY FOR 3 SECONDS	BREAK
a.c.	1250VA with maxima 5A and 660V	7500 VA with maxima 30A and 660V	1250VA with maxima 5A and 660V
d.c.	1250W with maxima 5A and 660V	7500W with maxima 30A and 660V	100W (resistive) 50W (inductive) with maxima 5A and 660V

CASES

The relay is supplied in a size 1 double ended drawout case (1D. DE), suitable for flush or projection mounting, finished bright black as standard.

Relays for use in exceptionally severe environments are finished to BS2011:20/50/56 at extra cost. Standard relays are finished to BS2011:20/40/4, and are satisfactory for normal tropical use.

CASE DIMENSIONS

Case Size	Height	Width	Depth *
1D DE	237mm	173mm	198mm

* Plus 21mm for maximum length of M5 screw terminals. Dimensioned drawings of case outlines, panel cutouts and mounting details are available on request.

INFORMATION REQUIRED WITH ORDER

Case finish and method of mounting.

Auxiliary a.c. voltage and frequency.

Suggested monitoring voltage, d.c.

Protective voltage setting a.c. or d.c.

Maximum voltage that structures could attain, i.e. protected equipment voltage to earth.

Number and type of contacts required on relay elements 64C and 64X.

Maximum value of fault current attainable on protected equipment.

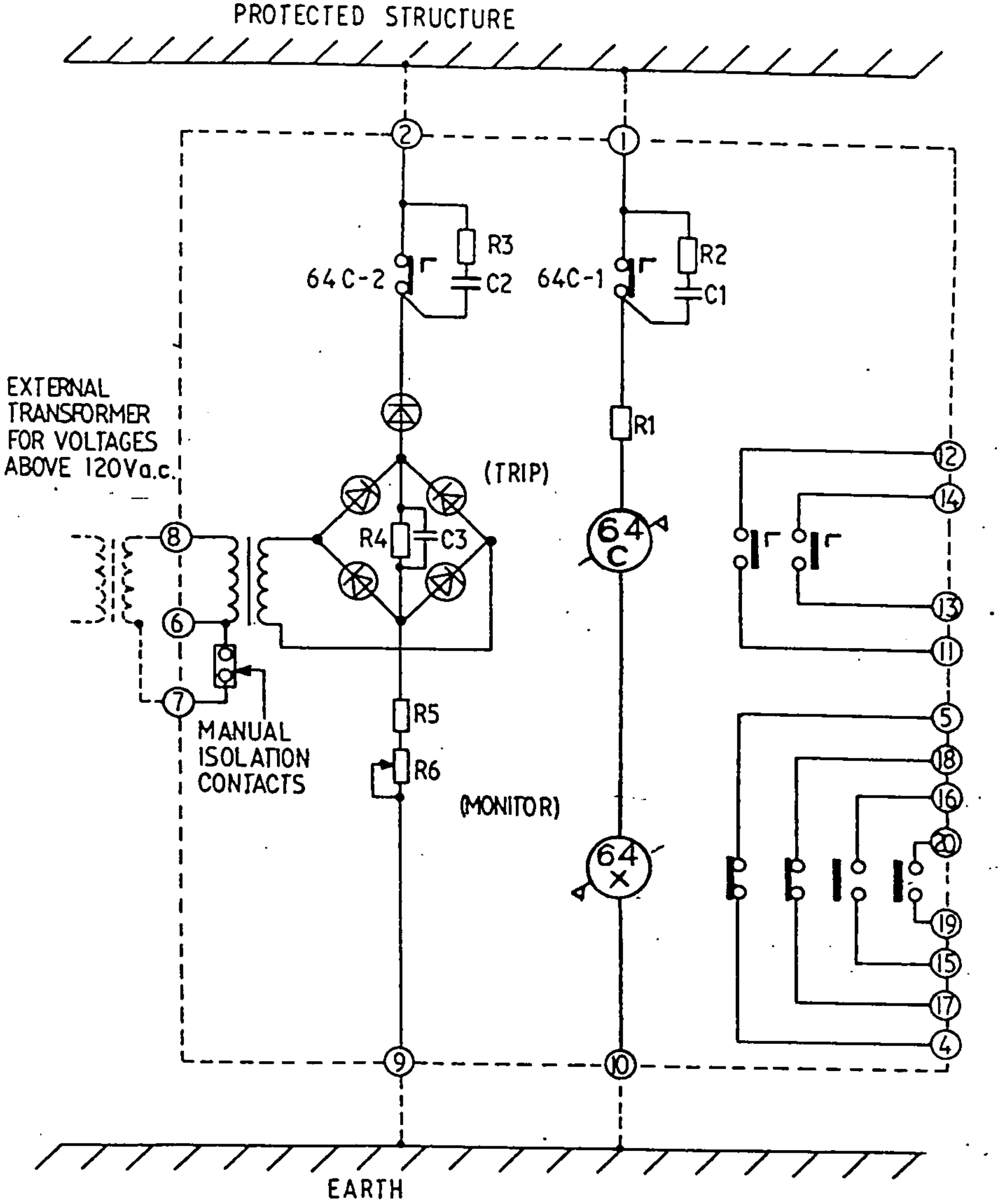


Figure 1 HIGH RESISTANCE EARTH FAULT RELAY

FOR FRENCH TRANSLATION SEE SHT. NO.

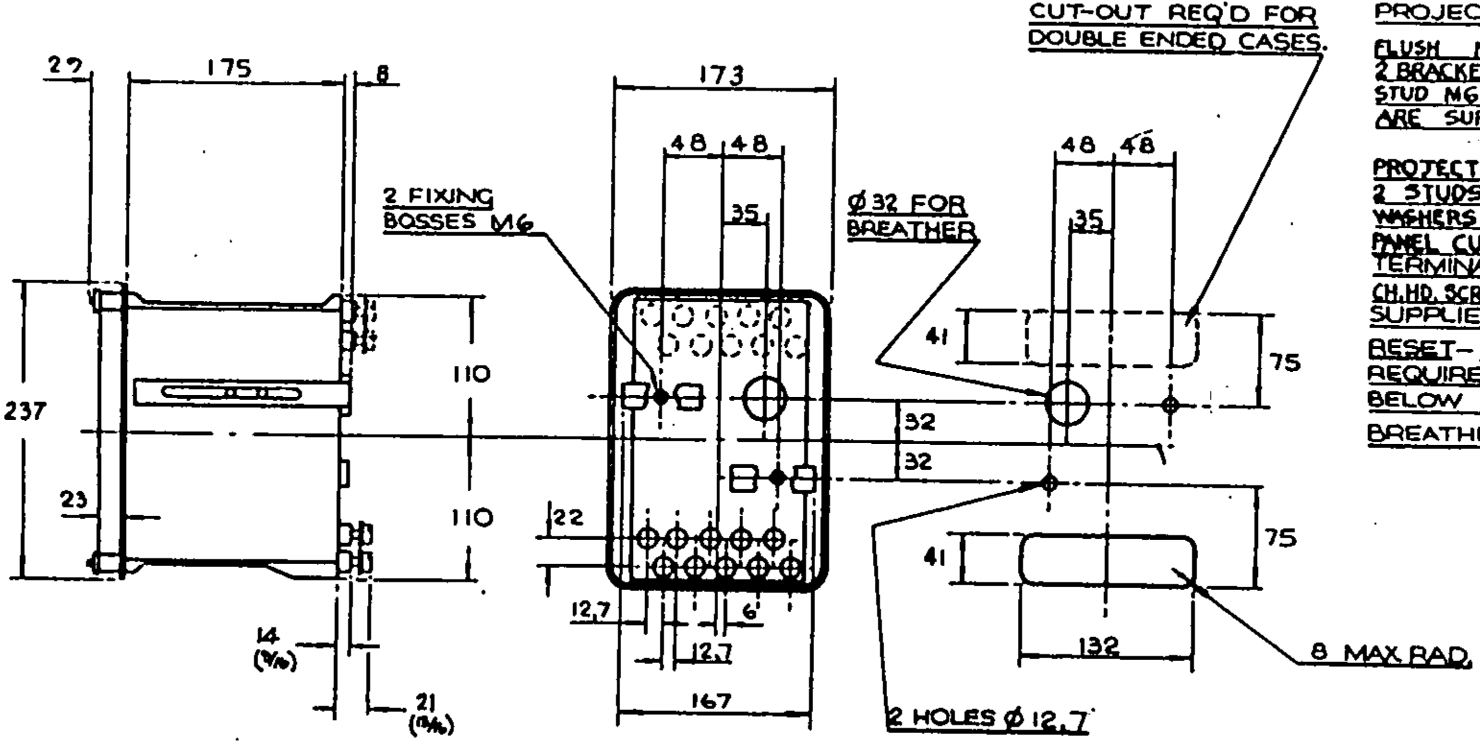
FG 0031 SHT 5

DO NOT SCALE

FOLD

THIRD ANGLE PROJECTION

DIMENSIONS ARE IN mm.



SIDE VIEW

REAR VIEW

PANEL CUT-OUT PROJECTING MOUNTING

PANEL CUT-OUT FLUSH MOUNTING. 222 X 150

TYPE AF/P & BF/P

NOTES.

GENERAL - CASES CAN BE SINGLE OR DOUBLE ENDED. FLUSH OR PROJECTING.

FLUSH MOUNTING AND EARTHING 2 BRACKETS, SCREW M6 X 10, STUD M6 X 40, NUTS & WASHERS ARE SUPPLIED.

PROJECTING MOUNTING & EARTHING. 2 STUDS M6 X 40, NUTS & WASHERS ARE SUPPLIED.

PANEL CUT OUT IS AS SHOWN.

TERMINALS. STD TERMINALS ARE M5 CH.HD. SCREWS. M5 STUDS CAN BE SUPPLIED ON REQUEST.

RESET - RESET PUSHRODS WHEN REQUIRED WILL PROJECT 6 mm BELOW FRONT FLANGE FACE.

BREATHERS - ONE.

A PREVIOUSLY ON FC 0031 SHT. DATE 15. 3. 70

B DATE 4. 12. 72 TRACED ON GEC SHEET STUDS AND BOSSES GIVEN METRIC REF.

C 24. 7. 74 PILLAR LENGTH WAS 51 (2) E2735. APR. 2

D R.Z.R. 9. 8. 76 [illegible]

E E.L. 24. 3. 80 BACK CONNECTED TERMINALS CHANGED [illegible]

GEC Measurements

THE GENERAL ELECTRIC COMPANY LIMITED.
ST. LEONARDS WORKS STAFFORD

TITLE OUTLINE & PANEL CUT-OUT DETAILS FOR SINGLE POLE (VERT) SINGLE & DOUBLE ENDED BACK CONNECTED DRAW-OUT CASE.

SCALE 1/4 FULL SIZE.

DRG. No	NEXT SHT.	DRAWN	CHECKED
FG 0031 SHT. 5	6.	KR	
		TRACED	APPROVED

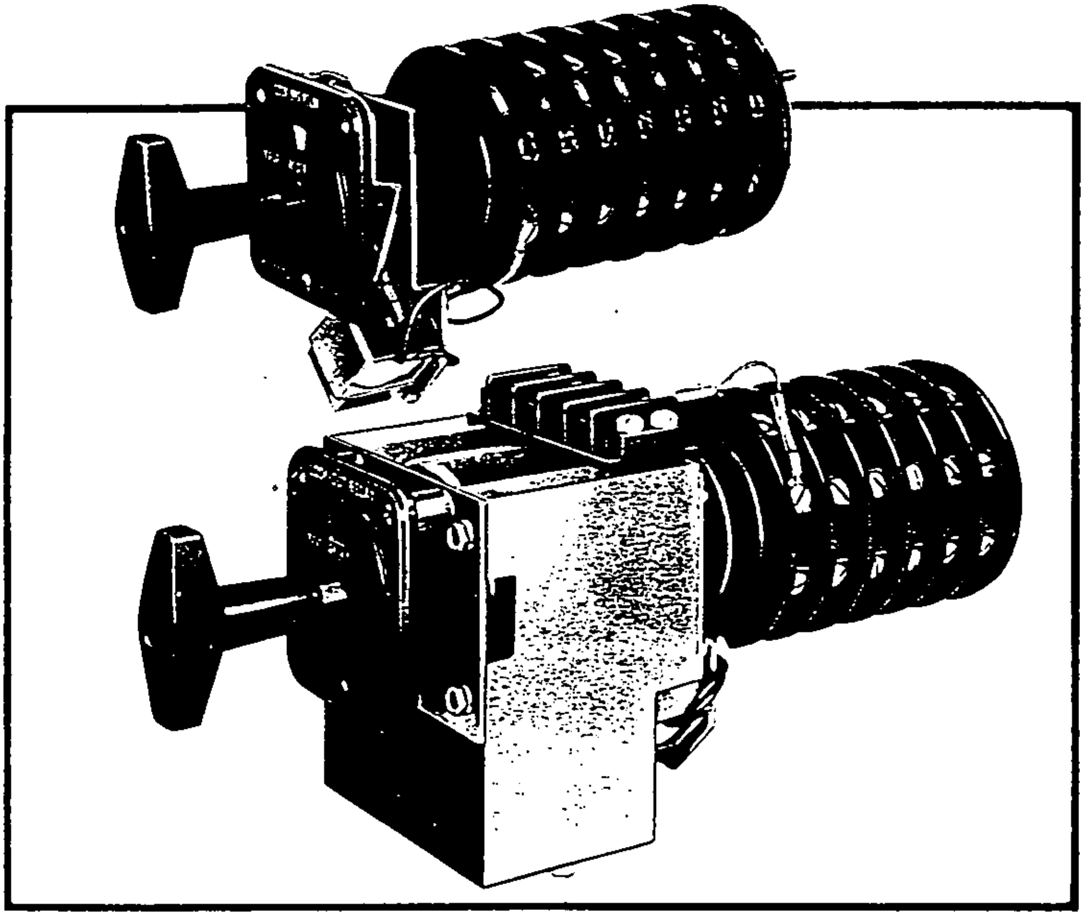
WHEN QUOTING THE DRAWING NUMBER PLEASE STATE THE LATEST LETTER OF ISSUE

Technical Publication

LOR-1

Effective April 15, 1987

HIGH SPEED
MULTI-CONTACT LOCK-OUT RELAYS
FOR POWER INDUSTRY APPLICATIONS



ELECTROSWITCH
UNIT OF ELECTRO SWITCH CORP.

180 King Avenue, Weymouth, Massachusetts 02188

Telephone: 617/335/5200

TWX: 710/388/0377

HIGH SPEED
MULTI-CONTACT LOCK-OUT RELAYS
FOR POWER INDUSTRY APPLICATIONS

ELECTROSWITCH
Weymouth, Massachusetts

ABSTRACT

The series 24 Lock-out Relays are high-speed (eight milliseconds) control relays used primarily as auxiliary relays in applications requiring many contacts (up to forty). The LOR is an electric-trip and manual-reset device. The LOR/ER is an electric-trip and either manual or electric-reset. The LOR/SR is an electric-trip and self-reset device. All units have mechanical position indicator targets. They are qualified to ESC-STD-1000 which includes aging and seismic vibration requirements to ANSI/IEEE 323-1984 and ANSI/IEEE-344-1975 for class IE uses in nuclear power generating stations. The testing also satisfies ANSI/IEEE C37.90-1978 and ANSI/IEEE C37.98-1978.

INTRODUCTION

Lock-out Relays of various types are often used in the electrical power industry. These auxiliary relays are electric-trip, manual or electric reset control relays for the purpose of tripping and locking out circuit breakers or other devices automatically when a fault or other predetermined condition exists. The lock-out relays are generally used in conjunction with differential relays to protect transformers, buses, and rotating machinery in various electrical systems.

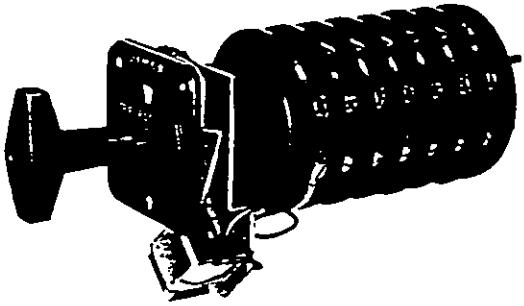


Fig. 1. Series 24 LOR Manual-reset Lock-out Relay

Initial Release - September 15, 1977
Revised - January 3, 1980
Added LOR/SR - February 1, 1983
Revised - March 15, 1985
Revised - April 15, 1987

Lock-out Relays of known types often have ten or more NO and NC contacts. The relays can be programmed to change sequences such as shutting down a faulty pump and then initiating the action to start-up a standby pump or bypassing a faulty circuit by opening and closing breakers.

Known relays of this type are normally latched in the RESET position and trip-out to a TRIP position when commanded. There are then manual-reset, electric-reset, and self-reset versions to get back to the RESET position.

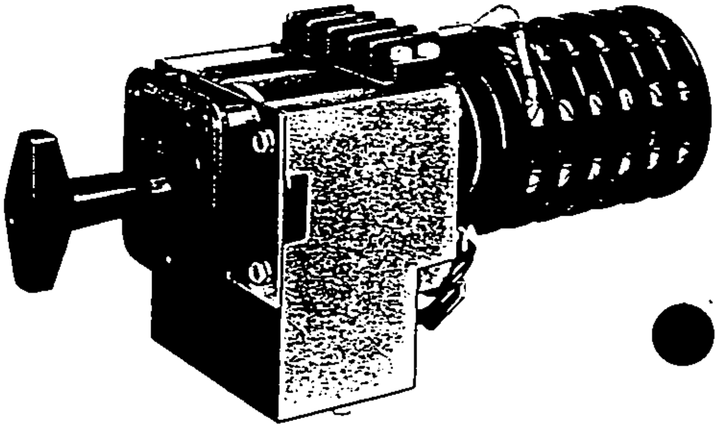


Fig. 2. Series 24 LOR/ER Electric-reset Lock-out Relay and LOR/SR Self-reset Lock-out Relay

High-speed, rugged, multi-contact units are needed. This paper describes a family of Lock-out relays with up to forty contacts that operate as quickly as eight milliseconds and are seismic shockproof.

BASIC CIRCUIT OPERATION

The control of the Lock-out Relays for operation as a relay requires no special wiring. They only require a NO contact (S1) to command the LOR to TRIP and the electric-reset LOR/ER needs an additional NO contact (S2) to initiate the command for RESET. The choice of S1 should take in consideration the burden data of trip coil, LOR/T, since S1 will "make" this current. This circuit is self-interrupting with the LOR contacts so S1 need not be concerned with the "break" of the TRIP circuit. On the electric-reset LOR S2 needs to make only the K1 relay circuit so the burden of LOR/R does not effect S2. Any pilot duty device is acceptable for both S1 and S2.

Manual-reset LOR Circuit

The LOR schematic is shown on Fig. 3.

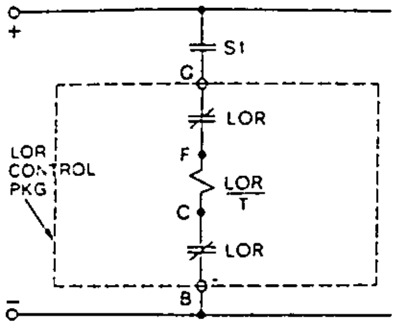


Fig. 3. Manual-reset LOR Control Circuit (shown in RESET position)

The standard station control bus voltage is used. The LOR, as shown, is in the RESET position. The LOR/T coil form represents the linear solenoid that releases a trigger that locks the LOR in the RESET position when the trigger is activated. The mechanical design is described later under THE ELECTRO-MECHANICAL DRIVE.

The LOR contacts shown are normally closed in the reset position. They are within the LOR control package. G and B are tie points to connect the LOR to the control circuit. C and F are internal connection points shown for information.

To command the Lock-out Relay to TRIP, S1 is closed. This completes a circuit across the LOR trigger solenoid, which operates, causing the device to snap to the TRIP position. It locks into this position and remains there indefinitely. When this happens, the LOR contacts open thereby removing the control circuit from the bus.

The unit will stay locked-out in the TRIP position until manually reset. S1 may be any kind of auxiliary contact -- from a breaker, a protective relay, or from another auxiliary device like a relay. The condition of the Lock-out Relay is visible by the handle location and a mechanical target within the nameplate (Black for RESET, Orange for TRIP).

Electric-reset LOR/ER Circuit

The LOR/ER schematic is shown on Fig. 4.

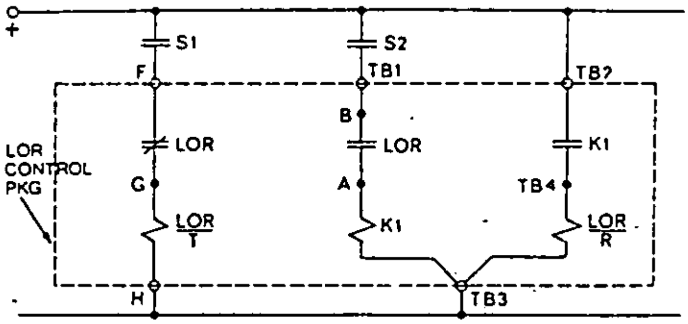


Fig. 4. Electric-reset LOR/ER Control Circuit (shown in the RESET position)

The electric-reset Lock-out Relay operates from the control bus voltage like the manual-reset version. The LOR/ER, as shown, is in the RESET POSITION. The LOR/T coil form is the same linear solenoid that is used in the manual-reset LOR, and controls the trigger that locks the LOR/ER in the RESET position. The LOR/R coil form represents the rotary solenoid that is used to reset the LOR/ER electrically. K1 is a relay used to control the rotary solenoid. This enables S2 to be a low level contact. It controls only the K1 relay coil. The K1 contact operates the high current rotary solenoid. TB1, TB2, TB3 are terminal block contacts, and F and H are LOR tie points -- all are for connection to the control bus. G, B, and TB4 are internal tie points shown for information.

The command of the LOR/ER to the TRIP position is the same as with the manual-reset LOR which was previously described. When tripped, the NC LOR contact in the LOR/T circuit opens removing LOR/T solenoid from the circuit. When this happens, the LOR NO contact in the K1 relay circuit closes enabling this circuit to be used.

To command the LOR/ER to reset, S2 is closed. This completes the circuit to the K1 relay and it operates closing contact K1. This completes the circuit to the LOR/R rotary solenoid and it indexes to the RESET position. When this happens, the NO LOR contact opens. This opens the circuit on the K1 relay coil. K1 relay drops out opening contact K1 that opens the rotary solenoid LOR/R circuit. At the same time the NC LOR contact, in the linear solenoid LOR/T circuit, closes, setting up the LOR/ER for the next TRIP command.

S1 and S2 should be momentary contacts and should not stay closed. If both contacts are closed at the same time, a "pumping" action will result with the LOR/ER indexing back and forth between the RESET and TRIP positions.

The handle and target indicators are the same on the standard electric-reset LOR/ER as the manual reset LOR. The handle on the high-speed LOR/ER is not an indicator and remains in the vertical position and the target must be manually reset (see page 9).

Self-reset LOR/SR Circuits

The self-reset Lock-out Relay operates from the control bus voltage like the LOR and LOR/ER. The LOR/SR, as shown in Fig. 5 and 6, is in the RESET position. The LOR/T coil is the same linear solenoid that is used in all LOR's, and controls the trigger that locks the LOR/SR in the RESET position. The LOR/R is the same rotary solenoid used in the LOR/ER and is used to electrically reset the LOR/SR. K1 and K2 are two relays with NO contacts used in the control circuit. B-A is a NO contact and E-F-G is a form C contact -- both in the control circuit. F-G is NC in the reset position while F-E is NO. TB1, TB2, TB3, and TB4 are terminal block connection points for the user. R1 and R2 make up a bridge circuit on both the INSTANTANEOUS RESET and the TIME DELAY RESET units. In addition the TIME DELAY RESET version has an additional 1E-1F normally open (NO) contact to isolate the K2 coil plus the time delay circuit consisting of R1 and C1-C2-C3-C4 which are wired in parallel. D1 protects the capacitors from a possible incorrect polarity hookup.

The INSTANTANEOUS RESET version of the LOR/SR will reset itself within 80 milliseconds after the fault has cleared itself (S1 opens). This circuit is illustrated in Fig. 5.

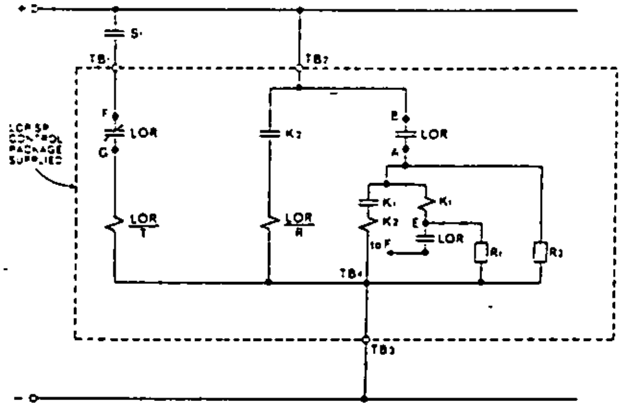


Fig. 5. Instantaneous-reset circuit for the self-reset (shown in RESET position) Lock-out Relay

The LOR/SR trips in the same manner as the manual-reset LOR. With S1 closed (simulating the commanded or fault condition) B-A contact closes and E-F contact closes. In this manner E-F and A-B are both connected to the (+) bus so the K1 coil sees no voltage difference and cannot operate. Therefore, the LOR/SR will not reset and may remain in the TRIP position indefinitely while the R1R2 bridge draws only enough milliamps to maintain the voltage balance of the bridge -- and well below the dropout current of any 0.2 amp. target relays that may be part of the circuit.

When S1 opens (indicating the fault or predetermined condition has cleared), the R1R2 bridge becomes unbalanced since the E-F contact, although closed, is in the S1 contact circuit. K1 operates, closing contact K1 and K2 operates, closing contact K2 and the rotary solenoid LOR/R operates and indexes to the RESET position completing the cycle.

Contact E-F, and A-B then open dropping out relays K1 and K2 (and their contacts). Contact F-G closes setting up LOR/SR for the next command.

The TIME DELAY SELF-RESET (shown in RESET position) version of the LOR/SR, illustrated in Fig. 6, operates in the same manner as the instantaneous reset version except the R3-C1-C2-C3-C4 circuit causes a time delay of from 300 to 600 milliseconds from the time S1 opens until the LOR/SR contacts reclose.

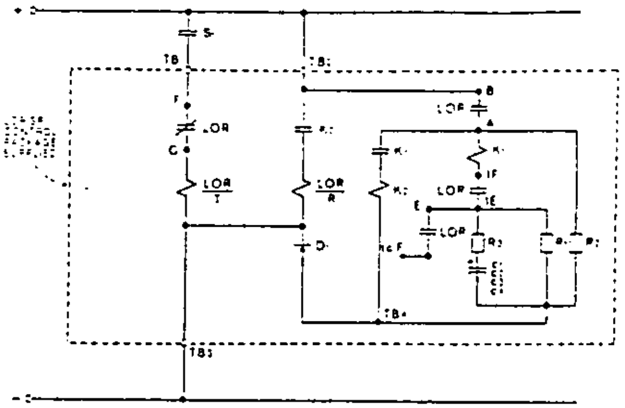


Fig. 6. Time-delay self-reset circuit for the LOR/SR

Operating Voltage

The LOR, LOR/ER, and LOR/SR Lock-out Relays are direct current actuated auxiliary relays. Because they are only actuated for short periods of time and are self-interrupting, they may be subjected to maximum design voltage indefinitely without exceeding 50°C temperature rise in ambient conditions as high as 55°C. This is using class 105 insulation and the applied thermocouple method of temperature determination.

The Lock-out Relays operate reliably over the full voltage ranges described in ANSI/IEEE C37.90-1978, the "Standard for Relays and Relay Systems Associated with Electric Power Apparatus."

These ratings are shown on Table I.

TABLE I

Coil Operating Range

COIL	NOMINAL VOLTAGE	NORMAL VOLTAGE OPERATING RANGE
A,B	24VDC	19.2 to 28VDC
C	48 VDC	38.4 to 56VDC
D,E,G	125VDC	100 to 140VDC
F,H	250VDC	200 to 280VDC

The trip and reset solenoid coils provide reliable operation over a wide latitude of operating conditions. Trip coils A, B, C, D, E, and F have substantial overlapping voltage ranges enabling some "custom-fitting" depending on desired speed versus current burden. Trip coils G and H have controlled threshold voltage levels to insure that the unit will not trip at half-voltage. G and H coils are useful where cummulative stray voltages due to capacitive and other effects might be impressed on the LOR coil causing occasional nuisance trips.

The full voltage ranges are shown on Tables II and III.

The Threshold Voltage shown is the minimum level that can produce a TRIP operation. This is not a reliable operation and this voltage level should not be normally used. The normal operation should be within the limits of the Operating Range.

The Operating Range represents the design limits for reliable operation. Safety factors are included so operation can occur above and below the indicated range as previously explained.

TABLE II

Trip Coil Voltage Data

COIL	NOMINAL VOLTAGE	THRESHOLD VOLTAGE	OPERATING RANGE
A	24VDC	6VDC	10 - 40VDC
B	24VDC	9VDC	18 - 50VDC
C	48VDC	12VDC	24 - 70VDC
D	125VDC	16VDC	30 - 140VDC
E	125VDC	23VDC	45 - 140VDC
F	250VDC	33VDC	70 - 280VDC
G	125VDC	70VDC	90 - 140VDC
H	250VDC	140VDC	180 - 280VDC

TABLE III

Reset Coil Voltage Data

COIL	NOMINAL VOLTAGE	OPERATING RANGE
A	24VDC	19.2 to 28VDC
C	48VDC	38.4 to 57.6VDC
D	125VDC	100 to 150VDC
F	250VDC	200 to 275VDC

Coil Burden Data

The LOR, LOR/ER, and ,LOR/SR solenoid coil burden data is outlined in Table IV.

As previously explained, the control bus needs to be able to supply the burden detailed in Table IV but does not need to interrupt it -- the units are self-interrupting. The reset coil is hard wired to the control bus so the actuating means (S2 on Fig.4) is not subjected to the burden (only the K1 coil burden at less than 1 ampere. S1 controlling the trip coil does "make" and carry the trip coil current.

TABLE IV

Coil Burden Data

COIL	COIL CIRCUIT VOLTS	TRIP COIL		RESET COIL	
		COIL CIRCUIT DC OHMS @25°C	BURDEN (AMPS) AT RATED VOLTAGE	COIL CIRCUIT DC OHMS @25°C	BURDEN (AMPS) AT RATED VOLTAGE
A	24VDC	3.3	7.3	.7	33.8
B	24VDC	7.7	3.1	—	—
C	48VDC	13.0	3.7	3.0	15.9
D	125VDC	27.0	4.6	12.4	10.1
E	125VDC	50.0	2.5	—	—
F	250VDC	104.0	2.4	80.6	3.1
G	125VDC	27.0	4.6	—	—
H	250VDC	104.0	2.4	—	—

Trip Coil Current - Voltage Characteristics

The trip coils may be used over a wide range of voltage levels as previously described. To aid in this selection Fig. 7 graphs the voltage/current characteristics of the trip coils. These values are the same for the manual-reset LOR, the electric-reset LOR/ER, and the self-reset LOR/SR Lock-out Relays. Fig. 7 is used with the Response Time graph of Fig. 8. Target selection data is detailed on Table V and VI and Fig. 9 to 12.

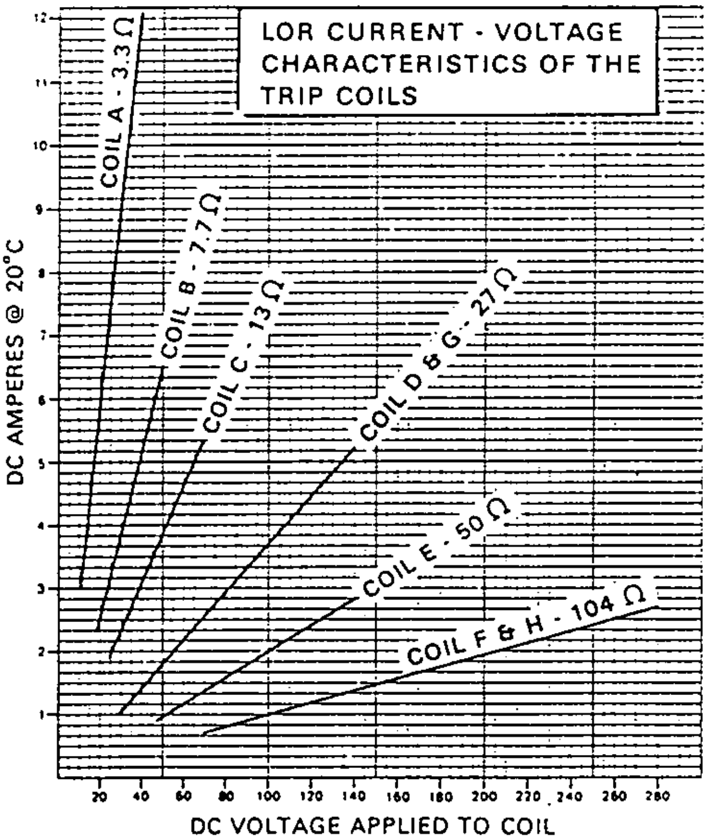


Fig. 7. Trip Solenoid Coil Burden Data

TABLE V

LOR Trip Coil Selection for Positive Target Operation

Operating DC Volts	LOR Trip Coils to Use	
	.2A Target	2A Target
24	A.B.C	
48	B.C.D.E	
100	D.E.F	
125	D.E.F.G	D
140	D.E.F	D
190	F	D
250	F.H	D

TABLE VI

Minimum Required DC Voltage for Positive Target Operation with Manual-Reset LOR

LOR TRIP COIL	no additional circuitry (Target)			2A Target resistor (Rp) in parallel		2A Target R-C Circuit		2A Target Series Resistor (Rs)		
	.2A	.6A	2A	25 Ohms	50 Ohms	40 MFD	20 MFD	7 Ohms	12.3 Ohms	16.7 Ohms
A										90
B	12	12	42						90	
C								95		
D	24	40	116		80	95	105			
E				75	105					
F	40	150		70	125					
G	90									
H	180									

Response Time - Trip Solenoid

Fig. 8 shows the high-speed response of the Lock-out Relays. The values given are total response to close NO contacts. The values are for ten deck LOR's and eight deck LOR/ER's and LOR/SR's. There is very little difference in smaller units. The response time of the trip coil of the high-speed electric-reset Lockout-relays is the same as the manual-reset LOR's.

Response Time - Reset Solenoid

The reset time of the electric-reset LOR/ER Lock-out Relays is generally not an important applications consideration so a graph has not been prepared. The response is approximately fifty milliseconds at rated voltage for all coils. The reset times of the self-reset LOR/SR is described on page 3.

Target used with Lock-out Relays

All the Lock-out Relays have a mechanical target as part of the nameplate -- Black for RESET and Orange for TRIP. This indicates the condition of the LOR. The target resets when the LOR resets (with the exception of the high-speed trip electric-reset LOR/ER and self-reset LOR/SR where the memory target is manually reset).

External targets may also be used in conjunction with the LOR's to show the condition of the devices that are being controlled. The most common .2A targets operate satisfactorily with any LOR. .6A targets are also generally satisfactory. 2A targets need special attention. Selection of LOR trip coils are shown in Table V with minimum required DC voltages for positive target operation shown on Table VI.

2A targets are generally slow acting. The response time of the LOR's is generally too fast for them to respond. From Tables V and VI it is seen that only trip coil D will respond and only at 118VDC or more. In order to use 2A targets at lower voltages suggested circuits have been developed. The standard circuit with no additional circuitry is shown on Fig. 9 for comparison. Fig. 10 to 12 are shown as suggested solutions. Table VI shows the minimum voltages to apply with these circuits to get positive 2A target operation.

These circuits were developed using target relays with coil characteristics shown on Table VII.

TABLE VII

Target Relay Coil Characteristics

Tests based on following Target coil characteristics	TARGET .2A	.6A	2A
Coil resistance (ohms)	8.15	.71	.195
Pull-in current (amps)	.15	.45	1.75

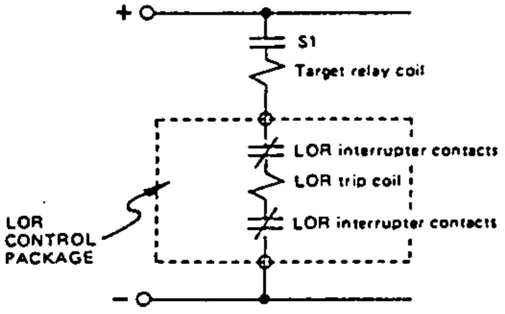


Fig. 9. Typical LOR trip circuit with target relay coil in series with LOR coil

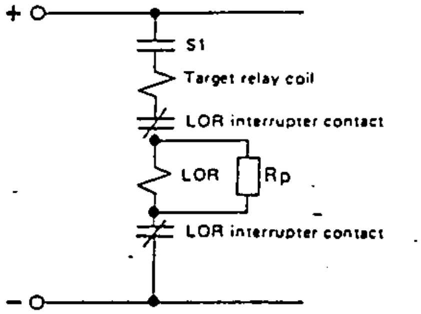


Fig. 10. LOR trip circuit with resistor (Rp) in parallel with LOR trip coil (not supplied with LOR -- see Table VI for recommended values)

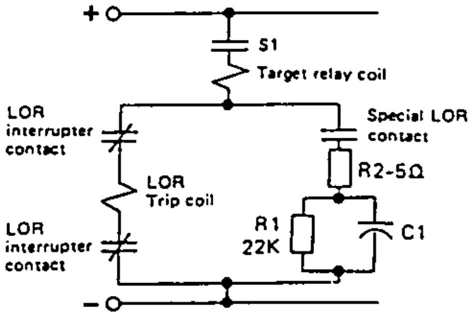


Fig. 11. LOR trip circuit with RC network -- momentarily connected with LOR coil increasing current in 2A target. C1 discharges through R1 when LOR is reset. See Table VI for recommended values of C1. Order special LOR

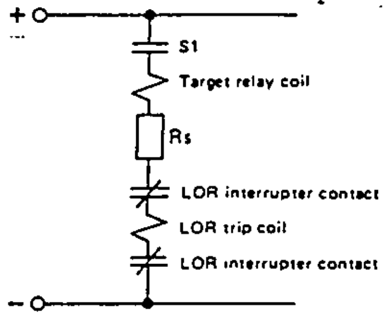


Fig. 12. LOR trip circuit with series resistor (Rs) chosen to reduce trip coil wattage. Value chosen to obtain 5 amperes for 5 milliseconds or longer through target relay coil. See Table VI for recommended values

Transient Protection

The LOR, LOR/ER, and LOR/SR Lock-out Relays are designed and tested to operate reliably in a normal power industry environment. This includes being subjected to transients on the control bus up to 3.5KV. Since the LOR is normally isolated from the

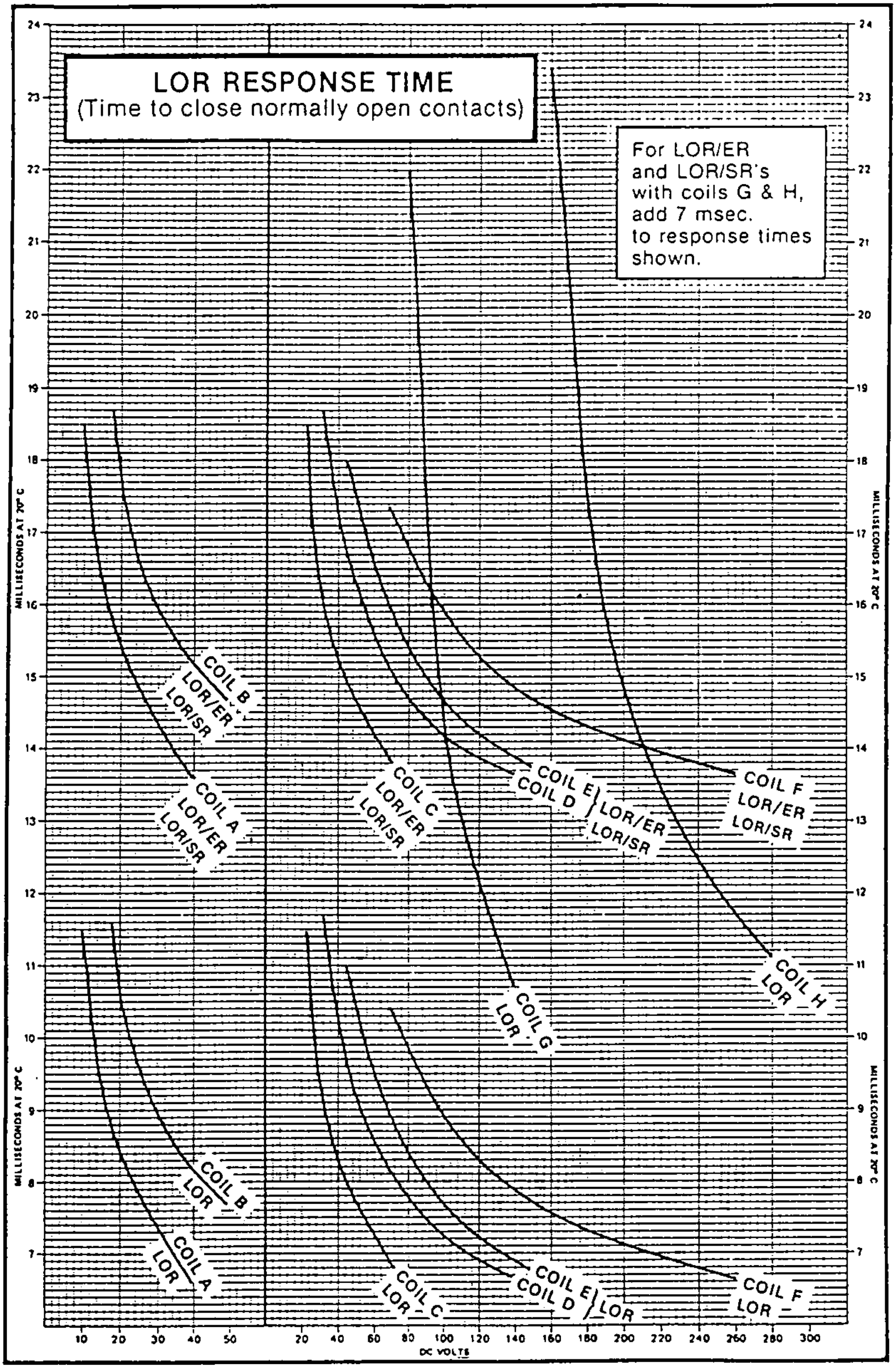


Fig. 8. LOR/ER, and LOR/SR Lock-out Relay Response Times (10 deck LOR, 8 deck LOR/ER, or LOR/SR). For high speed LOR/ER or LOR/SR's, use LOR response times.

bus, it will experience transients only if they occur in the operating mode. This precludes the possibility of a detrimental, accumulating affect over the life of the unit. As such, no transient protection is needed.

Because of the nature of the operation of the solenoid coils, the LOR does generate transients that may be of interest to the user. These transients are less than 2KV and generally in the 1.5KV to 1.8KV range.

BASIC RELAY CONTACTS

The LOR, LOR/ER, and LOR/SR Lock-out Relay contacts operate on the original, reliable principle of knife switches -- double sided, double-wiping, spring wiper blades closing on both sides of a terminal. To provide a closed contact, two terminals are bridged or shunted. Fig. 13 shows this contacting arrangement.

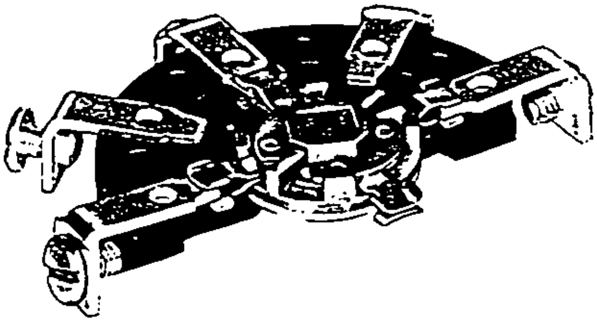


Fig. 13. Double-sided, double wiping knife-type contact configuration

Contact Materials

The wiper blades are made from a phosphor-bronze alloy that combines superior spring qualities with good electrical conductivity. This material and blade design has been proven by extensive laboratory testing as well as more than thirty years of field use and experience. Initially used in rugged naval ship applications, it is also used in industrial applications such as railroad locomotives and earth moving equipment. It has been used for more than thirty years in power industry applications, as well.

The blade assembly is shock-proof and virtually bounce-proof. This makes it ideal for high-speed, quick-make, quick-break devices like the LOR, LOR/ER, and LOR/SR.

The blades are formed, assembled, and riveted nearly closed. The gap is machine adjusted to provide a uniform high pressure. The gap does not change with time and use. Normal use tends to improve the contact surfaces due to the rubbing action. This provides a burnishing as well as cleaning action.

The contact surface conductivity is enhanced by a silver overlay stripe that lasts the life of the unit. This ensures a good contact even in those cases where the LOR, LOR/ER, and LOR/SR is not operated for long periods of time.

The terminals are made of electrically and environmentally compatible copper material with a silver overlay stripe at the contact area plus an overall silver plate to ensure a lastingly good contact surface fo customer wiring purposes. Similarly, th terminal screws are made from silver-plated brass.

Number of Decks Available

Table VIII shows the maximum number of decks and contacts available for reliable operation:

TABLE VIII

MAXIMUM DECKS AVAILABLE

LOR TYPE	MAXIMUM DECKS	MAXIMUM CONTACTS
LOR	10	40
LOR/ER-HI SPEED TRIP	10	40
LOR/ER-STD SPEED TRIP	8	32
LOR/SR INSTANT RESET	8	32
LOR/SR TIME DELAY RESET	7	·28

Contact Deck Arrangement

The blade and terminal configuration enables the use of multi-contacts in the same deck, and simple stacking procedures enable the fabrication of many independent contacts in one relay. Specifically, two NO contacts and two NC contacts are provided in each deck, and up to ten decks can be stacked, resulting in a relay with up to forty contacts (twenty NO and twenty NC). The deck arrangement is illustrated in Fig. 14.

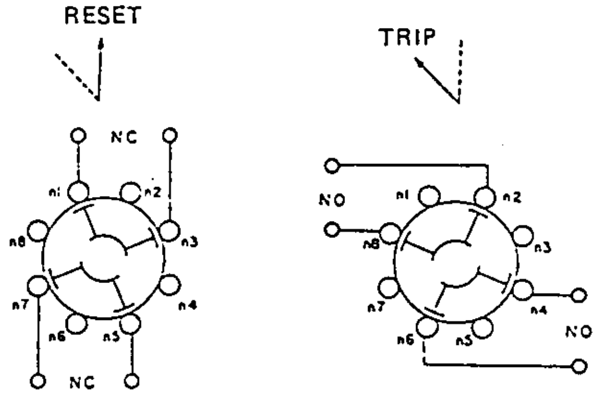


Fig. 14. Basic LOR Deck Layout

The illustration of Fig. 14 is for the first deck. For multideck units the second digit of the terminal number is the same as shown but the first digit changes to denote the deck number. As an example, terminal 82 is in the eighth deck, directly under terminal 12 and used together with terminal 88.

Contact Charts

The previous illustration shows how the LOR's are constructed and is shown as information for the user. Traditional contact charts are normally used, as shown on Fig. 15.

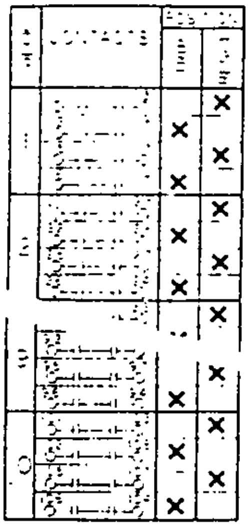


Fig. 15. LOR, LOR/ER, and LOR/SR, Lock-out Relay Contact Chart

Contact Ratings

The LOR, LOR/ER, and LOR/SR Lock-out Relays have been tested to many different circuit conditions. The interrupting ratings are based on 10,000 operations of life, using suddenly applied and removed rated voltage, with no extensive burning of contacts. Inductive ratings are based on tests using standard inductance L/R=0.04 for DC and $\cos\theta$=0.4 for AC. The Interrupting Rating Column headed "double contacts" means contacts in series. Short time, and continuous ratings are based on temperature rise in contact members and supporting parts not exceeding 50°C above ambient.

Allowable Variation From Rated Voltage

The relay contacts are not sensitive to normal variations in voltage. The interrupting capacity is important as indicated in Table IX. Variations of plus and minus twenty percent in rated voltage need not be considered as long as the interrupting current is not exceeded.

TABLE IX

Contact Ratings for
Series 24 LOR, LOR/ER, and LOR/SR
Lock-out Relays

CONTACT CIRCUIT VOLTS	INTERRUPTING RATING (AMPS)		SHORT TIME RATING (AMPS*)	CONTINUOUS RATING (AMPS)
	RESISTIVE SINGLE CONTACT	INDUCTIVE SINGLE CONTACT		
125VDC	3	1	60	30
250VDC	2	½	60	30
120VAC	20	15	60	30
240VAC	15	5	60	30
480VAC	10	5	60	30
600VAC	6	5	60	30

*Short time current is for one minute

THE ELECTROMECHANICAL DRIVE

The switching portion of the Lock-out Relay is the field proven series 24 Instrument and Control Switch. In this application it is a two position device -- TRIP and RESET. There is a powerful coil spring mechanism to drive it from the RESET position to the TRIP position. The device is held in the RESET position by a trigger locking mechanism. This is actuated by a small linear solenoid for electric tripping. The LOR is manually reset by rotating the handle against the coil springs. The LOR/ER is either manually reset or electrically reset utilizing a separate rotary solenoid mechanism. The LOR/SR is self-resetting when the tripping condition has been removed. These mechanisms are described below.

The TRIP Mechanism (Patent No. 3649793)

Industry requirements for Lock-out Relays include:

- high-speed
- seismic shock-proof
- multiple contacts

To get the multi-contact feature and maintain positive and rugged action, heavy spring action is required. This requires a locking mechanism to hold a spring wind-up of forty inch pounds of torque. To get high-speed release a solenoid is needed. Ordinarily a large solenoid is required to do this. Large solenoids are inherently slow so a small linear solenoid is used to release the latch. By nature small solenoids do not develop much torque so a mechanical advantage is needed.

The trigger mechanism was invented to provide the mechanical advantage. One pound of force from the linear solenoid releases the latch that locks the device against forty inch pounds of torque. The trigger uses the principle of coincident radii of two rollers -- one cannot roll without the other. The two rollers are shown in Fig. 16.

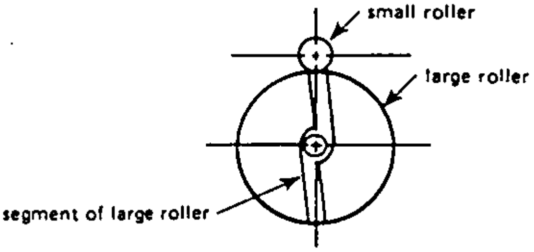


Fig. 16. Relationship of two rollers with coincident radii

The relationship of roller sizes is to get the mechanical advantage needed. Since only a small part of the larger roller is needed, a segment was cut out to reduce size and inertia.

Fig. 17 shows the small roller, large roller segment, and their relationships with the linear solenoid and the relay operating shaft.

As shown the trip mechanism is in the RESET position. This was done by rotating the handle [and relay shaft (1)] clockwise against the relay shaft stop pin (2). When the roller arm (3) [and the small roller (4)] clear the large roller segment (5), the retaining spring (6) positions the large segment (5) against the stop pin (7).

The handle and shaft (1) is now released, allowing the roller arm (3) to spring return counterclockwise until the small roller (4) comes to rest on the large roller segment (5). When the two rollers contact, the mechanical force generated acts along coincident radii (common centerline). Neither roller can rotate; the LOR is locked and reset.

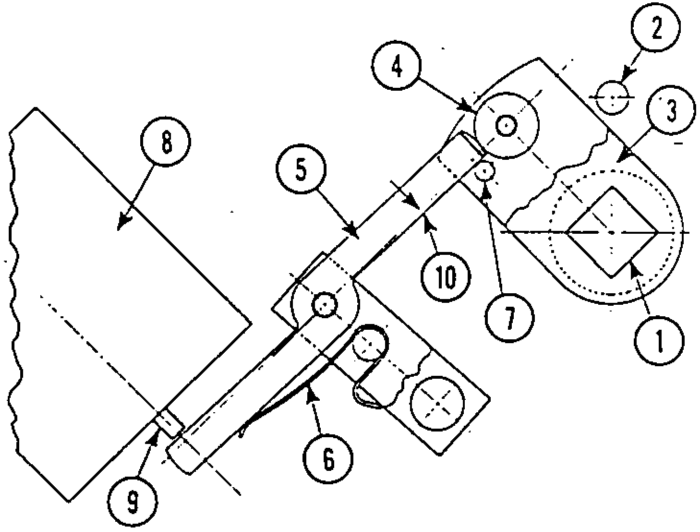


Fig. 17. LOR Trip mechanism

To initiate a TRIP action the linear solenoid (8) is actuated. The solenoid push rod (9) provides a one pound release force to the large roller segment (5) moving it by the release distance (10). When this happens, the roller arm (3) is free to rotate counterclockwise to the TRIP position where an internal stop mechanism stops the rotation.

The RESET Mechanism

The manual reset LOR is reset by manually turning the relay handle clockwise to the RESET position where it locks in. The electric-reset LOR/ER is either manually reset the same way or electrically reset using the solenoid circuit previously described. The LOR/SR self-resets with a solenoid circuit similar to the LOR/ER.

The HIGH-SPEED-TRIP Electric-reset Mechanism

The high-speed TRIP electric-reset or self-reset Lock-out Relay has two features used to accomplish a reliable tripping action in less than eight milliseconds:

1. The rotary solenoid is disengaged from the relay shaft after it is used to electrically reset the device. This reduces the drag on the relay shaft enabling the high-speed TRIP. The handle always resets in the vertical position, therefore, it is not used as a position indicator. It is used only to RESET the LOR/ER or LOR/SR manually. The TARGET is the position indicator.
2. The mechanical target indexes to TRIP (orange) when the LOR/ER or LOR/SR trips but does not reset to black when the LOR/ER or LOR/SR is electrically reset. The target is reset manually with a lever on the face of the nameplate. This enables a station operator to observe and record the fact that the LOR/ER or LOR/SR did TRIP -- a much less expensive method than using recorders.

VERIFICATION TESTING

The series 24 LOR, LOR/ER, and LOR/SR Lock-out Relays have been tested to many different service conditions to insure that they will operate satisfactorily as general devices -- not special use. For power industry applications the testing is performed in accordance with the following standards:

- ANSI/IEEE-323-1984
  Qualifying Class IE Equipment for Nuclear Power Generating Stations
- ANSI/IEEE-344-1975 Recommended Practices for Seismic Qualification of Class IE Equipment for Nuclear Power Generating Stations
- ANSI/IEEE C37.90-1978
  Relays and Relay Systems Associated with Electric Power Apparatus
- ANSI/IEEE C37.98-1978
  Seismic Testing of Relays

The testing is performed in accordance with ESC-STD-1000-General Specifications for Rotary Switches and Auxiliary Relays for Utility Applications including IE Equipment Requirements for Nuclear Power Generating Stations. The tests include ratings evaluation tests, aging tests to simulate forty years operating life, and seismic tests.

Aging Tests

Aging tests are run in accordance with ANSI/IEEE 323-1984 and ESC-STD-1000 and consist of the following (run in sequence):

1. Visual and mechanical examination
2. Circuit configuration
3. Dielectric Withstanding Voltage-2200VRMS
4. Insulation resistance - 100 megohms minimum at 500VDC
5. Contact resistance - 10 milliohms maximum at rated current
6. Radiation aging - 10 megarads (10^7)
7. Elevated temperature - 120 hours at 80°C
8. Elevated humidity - 96 hours at 95% RH
9. Temperature rise (contacts) - 50°C maximum
10. Aging - 10,000 cycles at 20A-120VAC and 3A-125VDC (both resistive)
11. Seismic vibration - ZPA=5g
12. After test measurements (in order) - items 3, 4, 5, 9, 2, 1

Details on the background of these tests plus the methods and procedures are outlined in ESC-STD-1000.

Seismic Tests

The series 24 LOR, LOR/ER, and LOR/SR Lock-out Relays are subjected to fragility testing in a seismic environment after aging to an accelerated life estimated to be forty years. This sequence is outlined under Aging Tests. The seismic tests are in accordance with ANSI/IEEE 344-1975 and ANSI/IEEE C37.98-1978. The tests are performed in accordance with ESC-STD-1000. Broadband repeatable multifrequency input motions are used. The Fragility Response Spectrum (FRS) envelopes the Standard Response Spectrum (SRS) shown in Fig. 18 using a biaxial input motion.

The "g" rating of the Lock-out Relays are defined as the ZPA (zero period acceleration). The "g" rating, then, is 5g. The series 24 LOR and LOR/ER were tested in the normal RESET position, the TRIP position, and during transition from RESET to TRIP. The LOR/SR was tested in the RESET position.

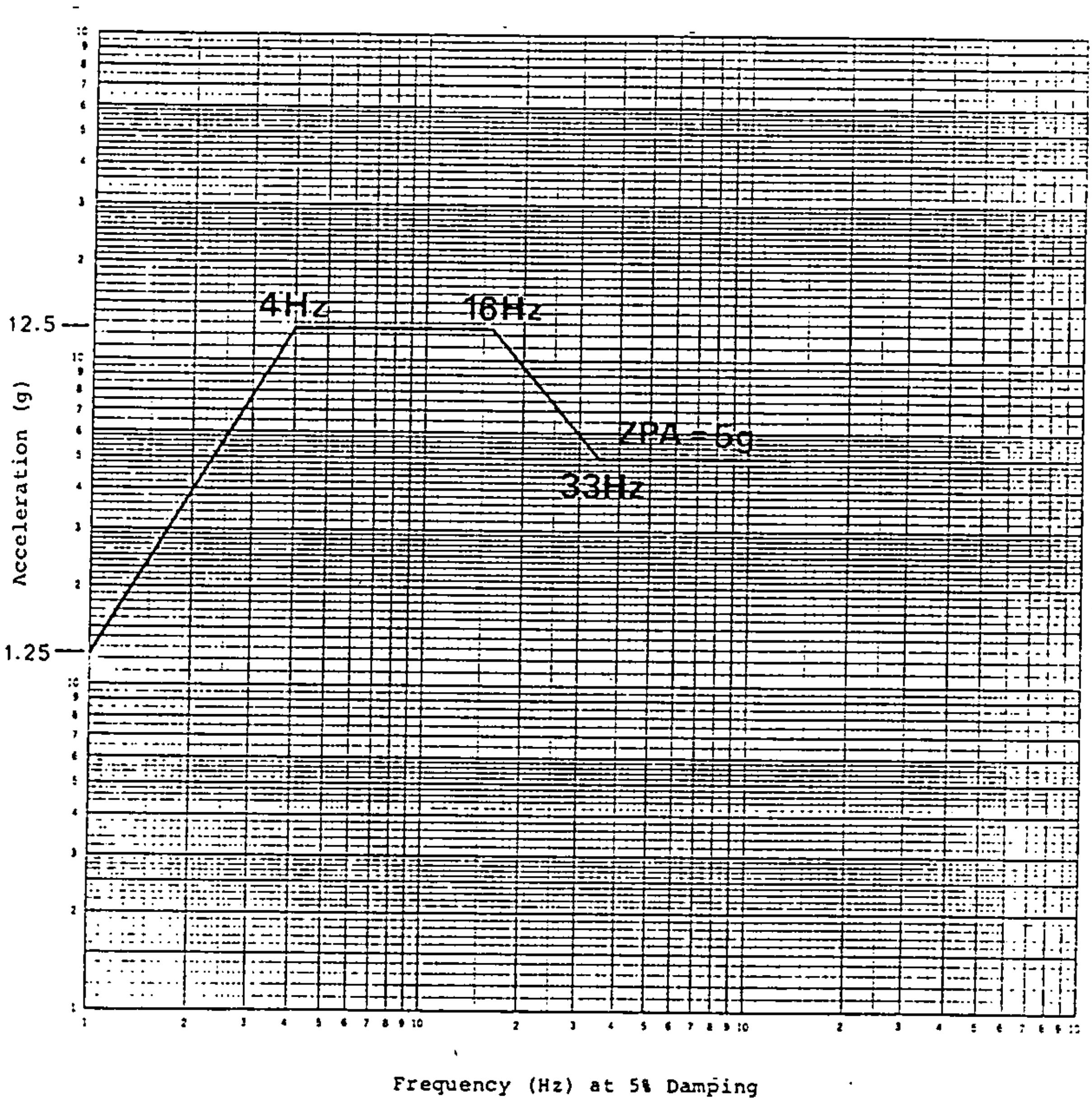


Fig. 18. Multi-frequency Broadband Standard Response Spectrum SRS)

HOW TO ORDER LOCK-OUT RELAYS

1. Select desired trip-coil from data on pages 4 and 6.
2. Select reset coil voltage from chart below.
3. Choose appropriate catalog number below.
4. Units are supplied with engraved nameplate (code 17C-2L22) unless otherwise specified.
5. For other than standard relays shown below (or for your own documentation purposes) complete DESIGN GUIDE (shown on pages 12, 13, 14).

MANUAL-RESET LOR

	Catalog Numbers for Trip-Coils							
Decks	Coil A	Coil B	Coil C	Coil D	Coil E	Coil F	Coil G	Coil H
1	7801A	7801B	7801C	7801D	7801E	7801F	7801G	7801H
2	7802A	7802B	7802C	7802D	7802E	7802F	7802G	7802H
3	7803A	7803B	7803C	7803D	7803E	7803F	7803G	7803H
4	7804A	7804B	7804C	7804D	7804E	7804F	7804G	7804H
5	7805A	7805B	7805C	7805D	7805E	7805F	7805G	7805H
6	7806A	7806B	7806C	7806D	7806E	7806F	7806G	7806H
7	7807A	7807B	7807C	7807D	7807E	7807F	7807G	7807H
8	7808A	7808B	7808C	7808D	7808E	7808F	7808G	7808H
9	7809A	7809B	7809C	7809D	7809E	7809F	7809G	7809H
10	7810A	7810B	7810C	7810D	7810E	7810F	7810G	7810H

STANDARD TRIP ELECTRIC-RESET LOR/ER

	Reset-Coil	Catalog Numbers for Trip Coils							
Decks	Voltage	Coil A	Coil B	Coil C	Coil D	Coil E	Coil F	Coil G	Coil H
3	24VDC	7823AA	7823BA	7823CA	7823DA	7823EA	7823FA	--	--
5	24VDC	7825AA	7825BA	7825CA	7825DA	7825EA	7825FA	--	--
8	24VDC	7828AA	7828BA	7828CA	7828DA	7828EA	7828FA	--	--
3	48VDC	7823AC	7823BC	7823CC	7823DC	7823EC	7823FC	--	--
5	48VDC	7825AC	7825BC	7825CC	7825DC	7825EC	7825FC	--	--
8	48VDC	7828AC	7828BC	7828CC	7828DC	7828EC	7828FC	--	--
3	125VDC	7823AD	7823BD	7823CD	7823DD	7823ED	7823FD	7823GD	--
5	125VDC	7825AD	7825BD	7825CD	7825DD	7825ED	7825FD	7825GD	--
8	125VDC	7828AD	7828BD	7828CD	7828DD	7828ED	7828FD	7828GD	--
3	250VDC	7823AF	7823BF	7823CF	7823DF	7823EF	7823FF	--	7823HF
5	250VDC	7825AF	7825BF	7825CF	7825DF	7825EF	7825FF	--	7825HF
8	250VDC	7828AF	7828BF	7828CF	7828DF	7828EF	7828FF	--	7828HF

HIGH-SPEED TRIP, ELECTRIC-RESET LOR/ER

	Reset-Coil	Catalog Numbers for Trip-Coils		
Decks	Voltage	Coil D	Coil E	Coil F
3	125VDC	7833DD	7833ED	7833FD
5	125VDC	7835DD	7835ED	7835FD
8	125VDC	7838DD	7838ED	7838FD
10	125VDC	7840DD	7840ED	7840FD
3	250VDC	7833DF	7833EF	7833FF
5	250VDC	7835DF	7835EF	7835FF
8	250VDC	7838DF	7838EF	7838FF
10	250VDC	7840DF	7840EF	7840FF

STANDARD TRIP, INSTANT-RESET, SELF-RESET LOR/SR

	Reset-Coil	Catalog Numbers for Trip-Coils			
Decks	Voltage	Coil D	Coil E	Coil F	Coil G
3	125VDC	7843DD	7843ED	7843FD	7843GD
5	125VDC	7845DD	7845ED	7845FD	7845GD
8	125VDC	7848DD	7848ED	7848FD	7848GD

STANDARD TRIP, TIME-DELAY RESET, SELF-RESET LOR/SR

	Reset-Coil	Catalog Numbers for Trip-Coils			
Decks	Voltage	Coil D	Coil E	Coil F	Coil G
3	125VDC	7853DD	7853ED	7853FD	7853GD
5	125VDC	7855DD	7855ED	7855FD	7855GD
7	125VDC	7857DD	7857ED	7857FD	7857GD

HIGH-SPEED TRIP, INSTANT RESET, SELF-RESET LOR/SR

	Reset-Coil	Catalog Numbers for Trip-Coils		
Decks	Voltage	Coil D	Coil E	Coil F
3	125VDC	7863DD	7863ED	7863FD
5	125VDC	7865DD	7865ED	7865FD
8	125VDC	7868DD	7868ED	7868FD

HIGH-SPEED TRIP, TIME-DELAY RESET, SELF-RESET LOR/SR

	Reset-Coil	Catalog Numbers for Trip-Coils		
Decks	Voltage	Coil D	Coil E	Coil F
3	125VDC	7873DD	7873ED	7873FD
5	125VDC	7875DD	7875ED	7875FD
7	125VDC	7877DD	7877ED	7877FD

ELECTROSWITCH
UNIT OF ELECTRO SWITCH CORP
Weymouth, Massachusetts 02188
Telephone 617/335/5200

SERIES 24 LOCK-OUT RELAY

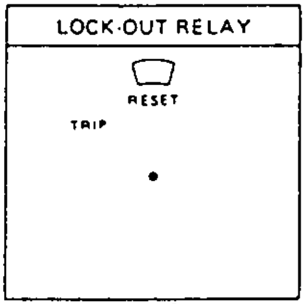
☐ MANUAL RESET
☐ ELECTRIC RESET
☐ HIGH SPEED ELECTRIC RESET

CATALOG NO. ________
ENGRAVING CODE: 17C-2L22
REV

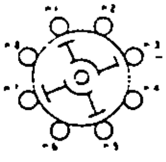
CONTACT DIAGRAM

DECK	CONTACTS	POSITION	
		TRIP	RESET
1	11 ○┤├─┤├○ 13		X
	12 ○┤├─┤├○ 18	X	
	15 ○┤├─┤├○ 17		X
	14 ○┤├─┤├○ 16	X	
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		

NAMEPLATE ENGRAVING



CONTACT DECK LAYOUT



TRIP COIL

NOMINAL VOLTAGE

☐ A – 24VDC
☐ B – 24VDC
☐ C – 48VDC
☐ D – 125VDC
☐ E – 125VDC
☐ F – 250VDC
☐ G – 125VDC
☐ H – 250VDC

Depth behind panel ________
Panel thickness ________

RESET COIL

NOMINAL VOLTAGE

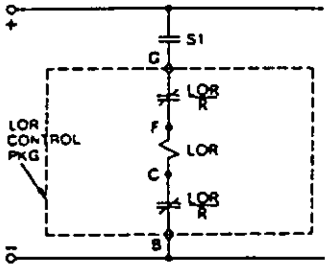
☐ A – 24VDC
☐ C – 48VDC
☐ D – 125VDC
☐ F – 250VDC

OTHER

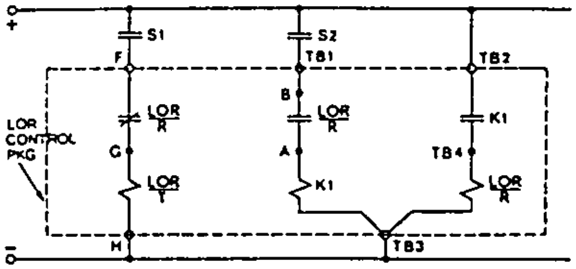
CONTROL CIRCUIT SCHEMATICS

shown in RESET position

MANUAL RESET LOR



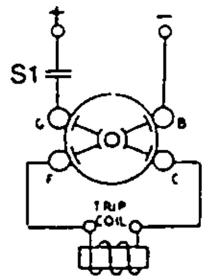
ELECTRIC RESET LOR/ER



WIRING DIAGRAMS – TRIP & RESET CIRCUITS

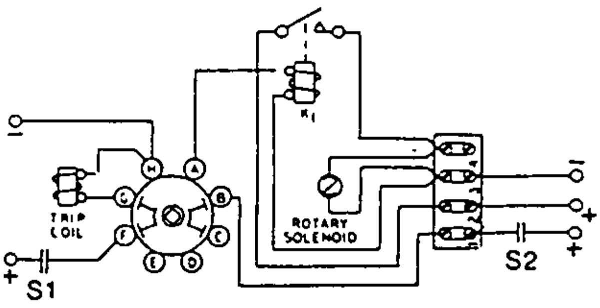
shown in RESET position

MANUAL RESET LOR



INTERRUPTER DECK	CONTACTS	POSITION	
		TRIP	RESET
	B ○┤├─┤├○ C		X
	F ○┤├─┤├○ G		X

ELECTRIC RESET LOR/ER



INTERRUPTER DECK	CONTACTS	POSITION	
		TRIP	RESET
	F ○┤├─┤├○ G		X
	A ○┤├─┤├○ B	X	

MADE BY: ________ DATE: ________
APPROVED: ________ DATE: ________
COMPANY: ________
DWG. NO. ________
SHEET ____ OF ____

ELECTROSWITCH
UNIT OF ELECTRO SWITCH CORP
Weymouth, Massachusetts 02188
Telephone 617/335/5200

SERIES 24 LOR/SR TIME DELAY, SELF-RESET LOCK-OUT RELAY

CATALOG NO. ____________

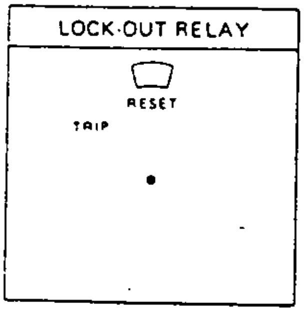
ENGRAVING CODE: 17C-2L22

REV

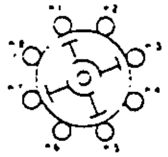
CONTACT DIAGRAM

DECK	CONTACTS	POSITION	
		TRIP	RESET
1	11 ○┤├─┤├○ 13		X
	12 ○┤├─┤├○ 18	X	
	15 ○┤├─┤├○ 17		X
	14 ○┤├─┤├○ 16	X	
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		
	○┤├─┤├○		

NAMEPLATE ENGRAVING



CONTACT DECK LAYOUT



n = deck number

TRIP COIL

NOMINAL VOLTAGE

☐ A – 24VDC
☐ B – 24VDC
☐ C – 48VDC
☐ D – 125VDC
☐ E – 125VDC
☐ F – 250VDC
☐ G – 125VDC
☐ H – 250VDC

Depth behind panel ____________

Panel thickness ____________

RESET COIL

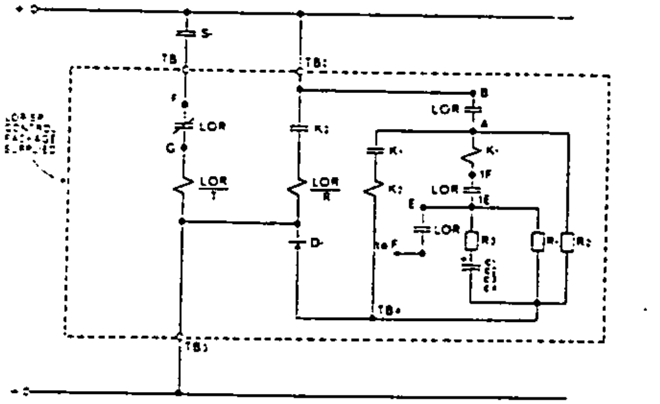
NOMINAL VOLTAGE

☐ D – 125VDC
☐

OTHER

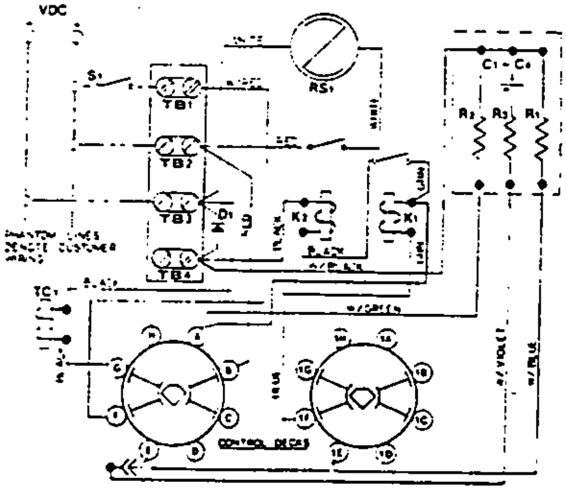
CONTROL CIRCUIT SCHEMATICS - LOR/SR

shown in RESET position



WIRING DIAGRAM - LOR/SR

shown in RESET position



CONTROL DECK	CONTACT	POSITION	
		TRIP (S1 CLOSED)	RESET (S1 OPEN)
	F ●┤├─┤├─● G		X
	A ●┤├─┤├─● B	X	
	F ●┤├─┤├─● E	X	
	1F ●┤├─┤├─● 1E	X	

DOCUMENT CONTROL
Quality Assurance -
ANSI/ASME NQA-1-1986
Qualification - ESC-Std-1000
Drawing Master
LOR/SR

MADE BY:	DATE:	COMPANY:	DWG. NO.
APPROVED:	DATE:		SHEET OF

ELECTROSWITCH
UNIT OF ELECTRO SWITCH CORP
Weymouth, Massachusetts 02188
Telephone 617-335-5200

SERIES 24 LOR/SR INSTANT SELF-RESET LOCK-OUT RELAY

CATALOG NO. ______

ENGRAVING CODE: 17C-2L22

REV

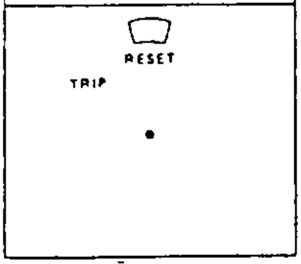
CONTACT DIAGRAM

DECK	CONTACTS	POSITION	
		TRIP	RESET
1	11 ○┤├┤├○ 13		X
	12 ○┤├┤├○ 18	X	
	15 ○┤├┤├○ 17		X
	14 ○┤├┤├○ 16	X	
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		
	○┤├┤├○		

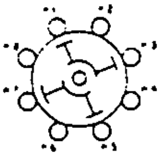
DOCUMENT CONTROL
Quality Assurance - ANSI/ASME NQA-1-1986
Qualification - ESC-Std-1000
Drawing Master
LOR/SR

NAMEPLATE ENGRAVING

LOCK-OUT RELAY



CONTACT DECK LAYOUT



n = deck number

TRIP COIL

NOMINAL VOLTAGE

☐ A – 24VDC
☐ B – 24VDC
☐ C – 48VDC
☐ D – 125VDC
☐ E – 125VDC
☐ F – 250VDC
☐ G – 125VDC
☐ H – 250VDC

Depth behind panel ______

Panel thickness ______

RESET COIL

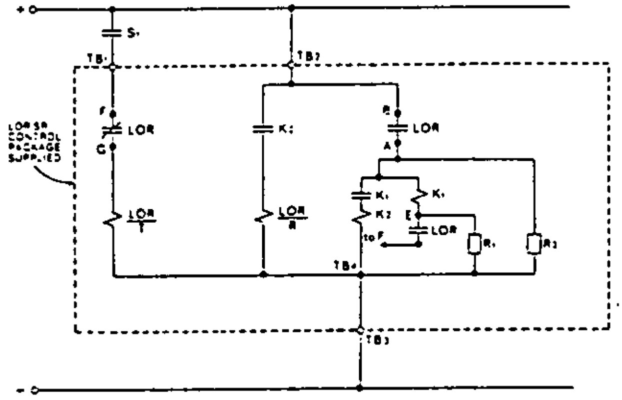
NOMINAL VOLTAGE

☐ D – 125VDC
☐

OTHER

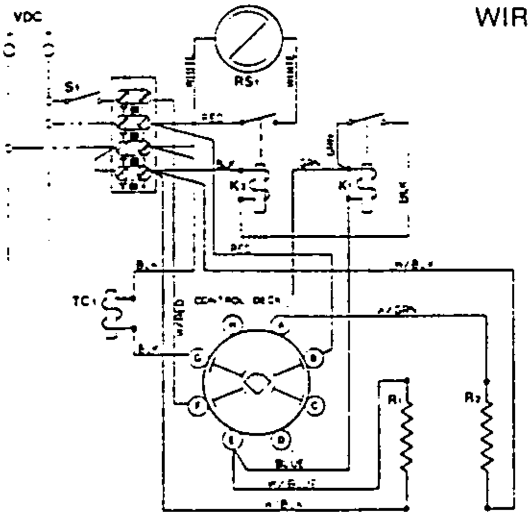
CONTROL CIRCUIT SCHEMATICS - LOR/SR

shown in RESET position



WIRING DIAGRAM - LOR/SR

shown in RESET position



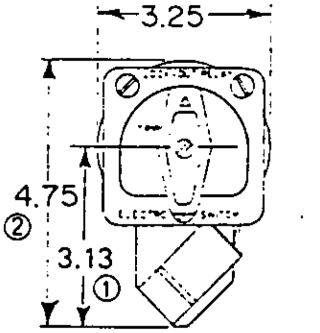
CONTROL DECK	CONTACT	POSITION	
		TRIP (S1 CLOSED)	RESET (S1 OPEN)
	F ●┤├┤├● G		X
	A ●┤├┤├● B	X	
	F ●┤├┤├● E	X	

MADE BY: | DATE:
APPROVED: | DATE:
COMPANY:
DWG. NO.
SHEET OF

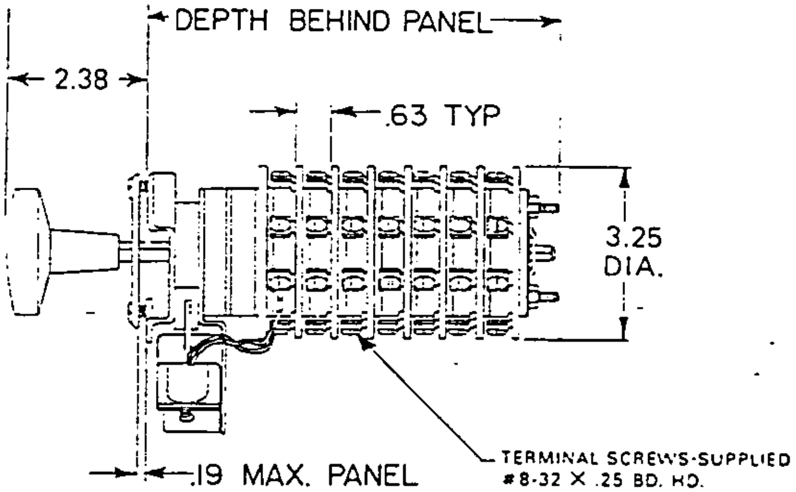
ELECTROSWITCH
UNIT OF ELECTRO SWITCH CORP
Weymouth, Massachusetts 02188
Telephone 617/335'5200

SERIES 24 LOR
LOCK-OUT RELAY

CATALOG NUMBERS
7801 to 7810 SERIES



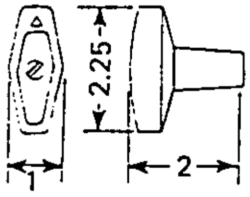
3 MOUNTING SCREWS SUPPLIED
#10-32 X :56



TERMINAL SCREWS-SUPPLIED
#8-32 X .25 BD. HD.

① 4.00 } for TRIP COILS G & H
② 5.62 }

HANDLE DIMENSIONS



CONTACT RATINGS

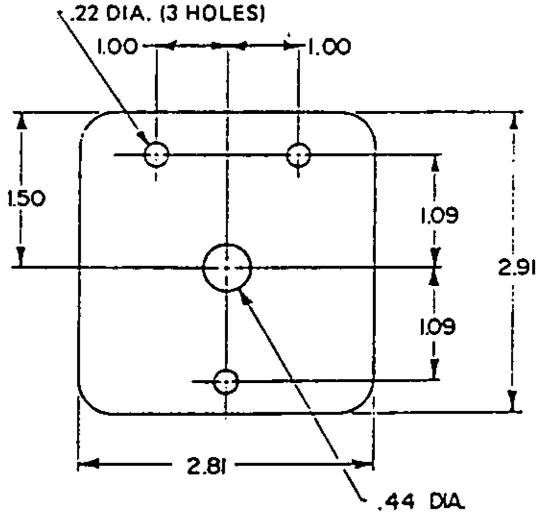
30A – 600V continuous
20A – 120VAC
15A – 240VAC
6A – 600VAC
3A – 125VDC

NOTES:

Complete technical data is outlined in Technical Publication LOR-1.

Contacting and wiring diagrams are shown on specific relay drawings.

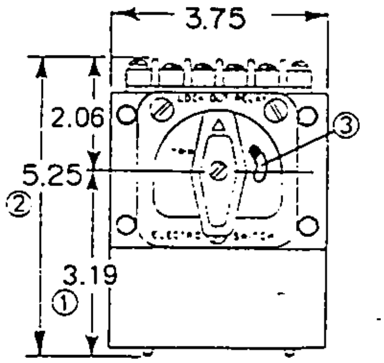
NAMEPLATE DIMENSIONS AND PANEL DRILLING



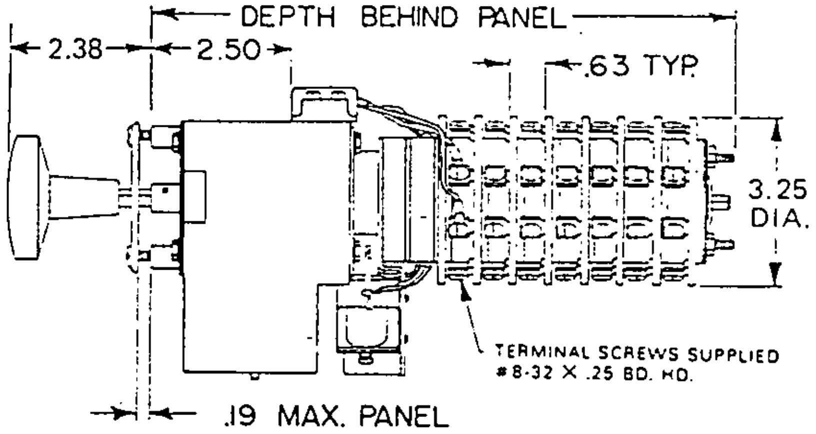
DEPTH BEHIND PANEL	
NUMBER OF DECKS	DEPTH INCHES
1	3.63
2	4.38
3	4.75
4	5.50
5	6.25
6	7.50
7	8.13
8	8.50
9	9.25
10	9.63

MADE BY: *a m*	DATE: *12-4-79*	MASTER DRAWING	DWG. NO: LOR	REV
APPR. BY: *KHL*	DATE: *12-4-79*		SHEET 1 OF 1	

ELECTROSWITCH UNIT OF ELECTRO SWITCH CORP Weymouth, Massachusetts 02188 Telephone: 617/335/5200	SERIES 24 LOR/ER, LOR/SR ELECTRIC-RESET & SELF-RESET LOCK-OUT RELAYS	CATALOG NUMBERS 7821 to 7878 SERIES



3 MOUNTING SCREWS SUPPLIED
#10-32 X .56

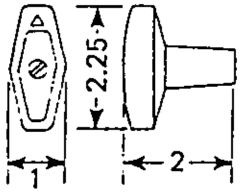


① 4.06
② 6.12 } for TRIP COILS G & H

③ Memory target for high-speed trip units

① 3.93
② 5.99 } for LOR/SR

HANDLE DIMENSIONS



CONTACT RATINGS

30A – 600V continuous
20A – 120VAC
15A – 240VAC
6A – 600VAC
3A – 125VDC

NOTES:

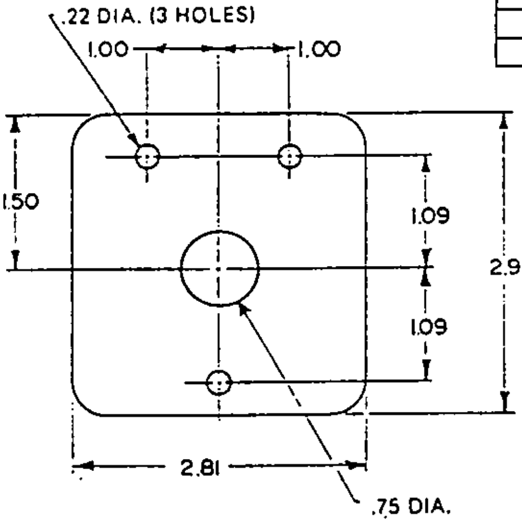
Complete technical data is outlined in Technical Publication LOR-1.

Contacting and wiring diagrams are shown on specific relay drawings.

DEPTH BEHIND PANEL (INCHES)

NUMBER OF DECKS	HIGH SPEED TRIP LOR/ER	LOR/ER AND INSTANT LOR/SR	TIME DELAY RESET LOR/SR
3	8.00	8.00	8.63
5	9.75	9.75	10.38
7	—	—	11.63
8	11.63	11.63	—
10	12.90	—	—

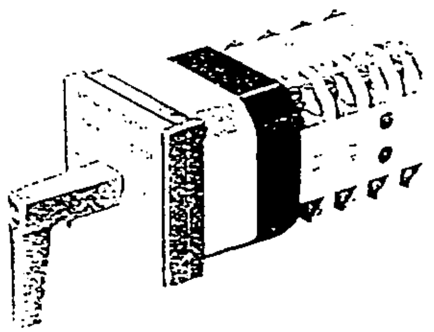
NAMEPLATE DIMENSIONS AND PANEL DRILLING



REVISIONS: Ⓐ ECN # 13342 1/17/83 Ⓑ ECN # 15870 4/1/87 JR

MADE BY: am	DATE: 12-4-79	MASTER DRAWING	DWG. NO: LOR/ER & LOR/SR	REV
APPR. BY: KHL	DATE: 12-4-79		SHEET 1 OF 1	B

Technical Publication MIN-1



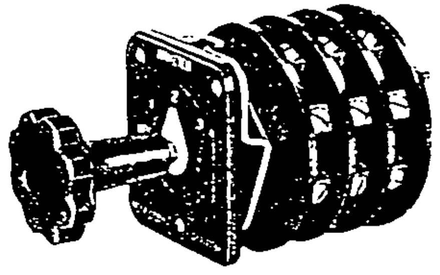
SERIES 20

MINIATURE INSTRUMENT & CONTROL SWITCH

20A-600VAC

1 to 12 decks 2 to 24 contacts

Technical Publication 24-1



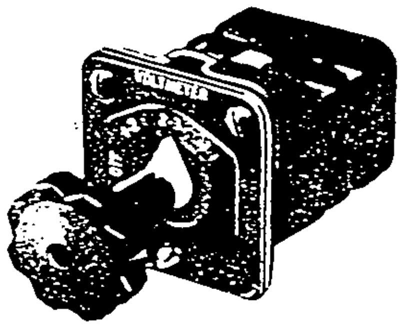
SERIES 24

STANDARD INSTRUMENT & CONTROL SWITCH

20A-120VAC . 6A-600VAC

1 to 10 decks 2 to 20 contacts

Series 20 & 40 DIGEST



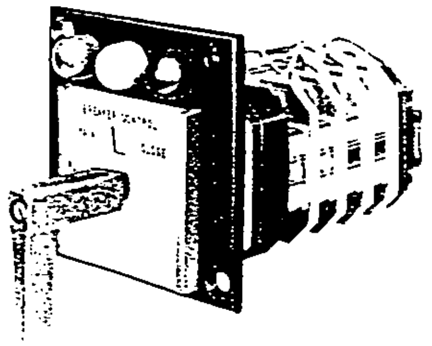
SERIES 40

CAM-ACTUATED INSTRUMENT & CONTROL SWITCH

32A-600VAC

1 to 12 decks 2 to 24 contacts

Technical Publication MIN-1



SERIES 20P

LIGHTED INSTRUMENT & CONTROL SWITCH

20A-600VAC

1 to 12 decks 2 to 24 contacts

POWER INDUSTRY PRODUCTS

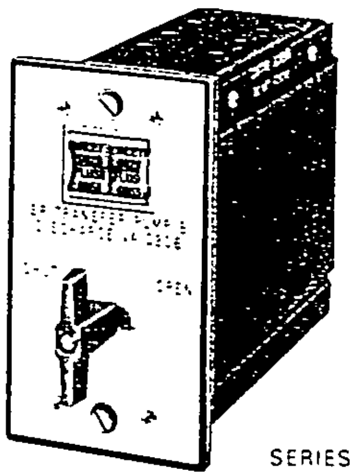
are qualified by laboratory testing to the following standards:

ANSI/IEEE 323-1984 (Environment)
ANSI/IEEE Std 344-1975 (Seismic)
ANSI/IEEE C37.90-1978 (General)
ANSI/IEEE C37.98-1978 (Seismic)

We also conform to:

NRC 10CFR21
NRC 10CFR50, Append. B
ANSI/ASME NQA-1-1986

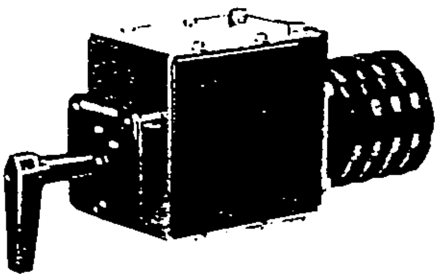
Technical Publication MOD-1



SERIES 20

PLUG-IN MODULE INSTRUMENT & CONTROL SWITCH

Technical Publication LSR-1



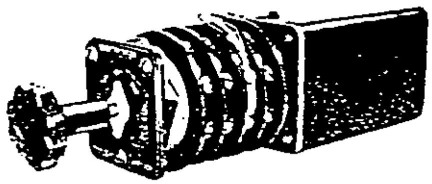
SERIES 24 LSR

LATCHING SWITCH RELAY

2 to 20 contacts

30 msec transfer time

Technical Publication SSR-1



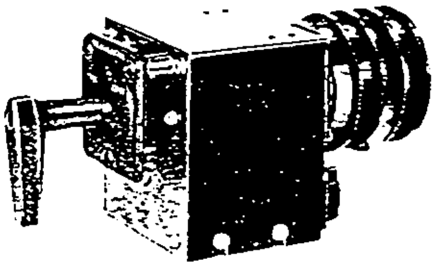
SERIES 24 SSR

ELECTRICALLY OPERATED SELECTOR SWITCH RELAY

Multi-contact auxiliary relay

2 to 8 positions

Technical Publication CSR-1



SERIES 24 CSR

CONTROL SWITCH RELAY

Replaces manual instrument & control switches

2 to 20 contacts

20A-120VAC

ELECTROSWITCH
UNIT OF ELECTRO SWITCH CORP.

180 King Avenue, Weymouth, Massachusetts 02188
Telephone: 617/335/5200 • TWX: 710/388/0377

KRPA series

GENERAL PURPOSE
5 and 10 AMP
MULTICONTACT
AC OR DC RELAY

UL File E22575
CSA File LR15734

GENERAL INFORMATION

The KRPA is a general purpose relay enclosed in a clear polycarbonate dust cover. This UL recognized, CSA certified relay is available with either silver contacts, rated 5 amps, or silver-cadmium oxide contacts, rated 10 amps. Contact arrangements from 1 Form A (SPST-NO) to 3 Form C (3PDT) are offered.

Ruggedly constructed for long operating life, KRPA relays are ideal for many varied applications. Octal-type plug termination allows rapid installation.

For voltage or current monitoring applications, KRPA-L and KRPA-N models each have an indicator lamp which lights when power is applied to the relay coil. KRPA-L has silver contacts, and KRPA-N has silver-cadmium oxide contacts. Only KRPA-L and -N models with 120-277V AC or 110V DC coils are UL recognized and CSA certified. Indicator lamp is not available with 25-90V coils.

ENGINEERING DATA

GENERAL

Insulation: molded high dielectric material
Initial insulation resistance: 1000 megohms
Initial breakdown voltage: 500V rms between open contacts, 1500V rms between all other elements
Temperature range: AC coils: −45°C to +55°C
DC coils: −45°C to +70°C
Typical time values for DC relays (bounce time not included):
Pick-up time @ Nom. voltage, +25°C: 15 milliseconds
Drop-out time @ Nom. voltage, +25°C: 10 milliseconds
Termination: 8- or 11-pin octal-type plug
Enclosure: Transparent, high-impact polycarbonate dust cover.
Approximate weight: 3 oz. (85 g)

CONTACTS

Arrangements: From 1 Form A (SPST-NO) to 3 Form C (3PDT) See Ordering Information table.
Material: Silver or silver-cadmium oxide. Consult factory for other materials.
Rating: UL Contact Ratings:
Silver contacts (codes Y & L)—all contact arrangements: 5 amps @ 120V AC; 3 amps @ 240V AC; 1/10 HP @ 120V AC; 1/6 HP @ 240V AC.
Silver-cadmium oxide contacts (codes G & N)—1 & 2 pole models: 10 amps @ 250V AC; 1/6 HP @ 120V AC; 1/3 HP @ 250V AC.
3 pole models: 10 amps @ 120V AC; 6 amps @ 250V AC; 1/6 HP @ 120V AC; 1/3 HP @ 250V AC.
Expected life: Electrical: 100,000 operations, minimum, at rated load.
Mechanical: 10 million operations, minimum.

COILS

Voltages: to 277V AC, 50/60 Hz. and to 125V DC
Power @ +25°C: AC: 2 volt-amperes nominal
DC: 1.2 watts nominal
125 mW per movable arm, minimum
3 watts maximum
DC coils requiring as little as 125 mW per movable arm are available. Consult factory.
Pick-up @ +25°C: AC: 85% or less of nominal voltage
DC: 75% or less of nominal voltage
Duty: continuous

COIL DATA

DC COILS			AC COILS (50/60 Hz.)		
Nominal Voltage	Resistance in Ohms ±10% @ +25°C	Nominal Current in Milliamps	Nominal Voltage	Resistance in Ohms ±15% @ +25°C	Nominal Current in Milliamps
6	32	188	6	6	335
12	120	100	12	24	168
24	472	51	24	85	84
48	1,800	26.6	120	2,250	17.5
110	10,000	11.5	240	9,110	8.75
220	Use 110V relay with 10,000 ohm 5W resistor in series				

ORDERING INFORMATION

Sample Part No. ►	KRPA	5	A	Y	12

BASIC SERIES – KRPA

CONTACT ARRANGEMENT:
1 = 1 Form A (SPST-NO)
2 = 1 Form B (SPST-NC)
3 = 1 Form X (SPST-NO-DM)
4 = 1 Form Y (SPST-NC-DB)
5 = 1 Form C (SPDT)
6 = 1 Form Z (SPDT[DB-DM])
7 = 2 Form A (DPST-NO)
8 = 2 Form B (DPST-NC)
11 = 2 Form C (DPDT)
12 = 3 Form A (3PST-NO)
13 = 3 Form B (3PST-NC)
14 = 3 Form C (3PDT)

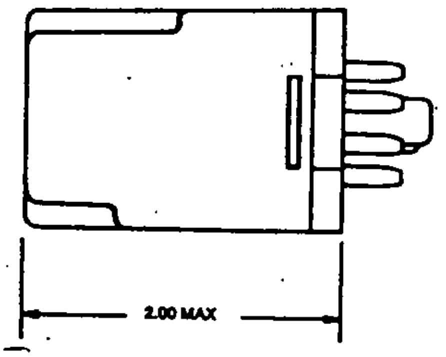
COIL INPUT:
A = AC, 50/60 Hz.
D = DC

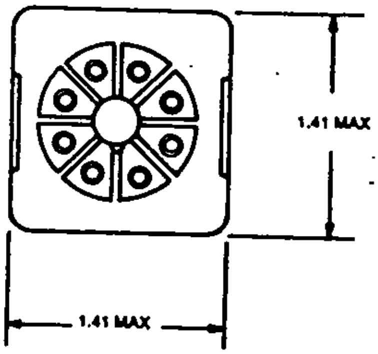
CONTACT MATERIAL & INDICATOR LAMP OPTION:
Y = Silver contacts, no indicator lamp
G = Silver-cadmium oxide contacts, no indicator lamp
L = Silver contacts, with indicator lamp*
N = Silver-cadmium oxide contacts, with indicator lamp*

COIL VOLTAGE:
To 277V AC, 50/60 Hz. or 125V DC

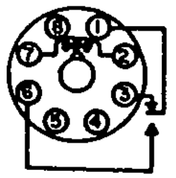
*Indicator lamp is not available on models with 25-90V coils. Only 120-240V AC and 110V DC models are UL recognized and CSA certified.

OUTLINE DRAWINGS

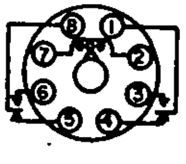




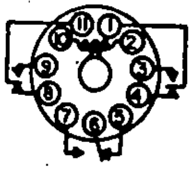
WIRING DIAGRAMS



KRPA 5



KRPA 11



KRPA 14

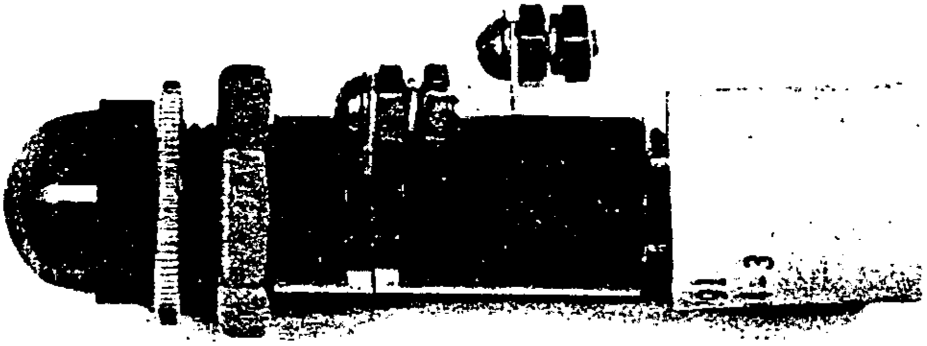
SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
13C207 3-82 PRINTED IN U.S.A. S3

AMF
Potter & Brumfield
Princeton, Indiana 47671 812/386-1000
TWX: 810-350-2343 TELEX: 278451

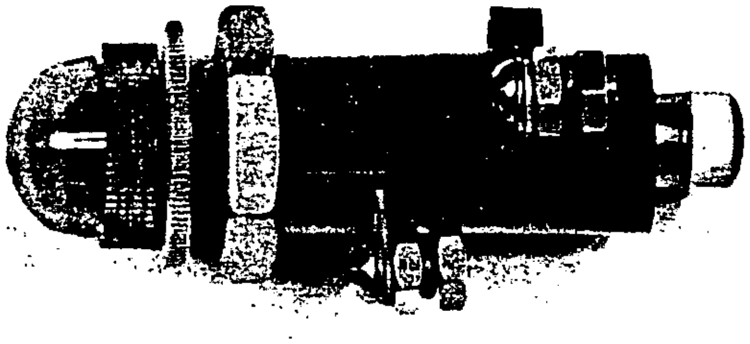
INSTRUCTIONS

GEH-3500 B
Supercedes GEH-3500 A

INDICATING LAMPS
TYPE ET-16 and ET-17



ET-16 INDICATING LAMP



ET-17 INDICATING LAMP

GENERAL ELECTRIC

CONTENTS

INTRODUCTION

The ET-16 (incandescent) and ET-17 (neon) indicating lamps consist of a common receptacle, plug in type resistors and lamps, escutcheon and color cap. Available for mounting on switchboard panels up to and including 1/4 inch thickness.

APPLICATION

These lamps can be used whenever a panel mounted signal or indicating lamp is desired.

The ET-16 is available for either one brilliance, or dim bright operation. The ET-17 can be used when extra long life is a factor and brilliance is not. It also can be used when low current is desired.

FEATURES

1. The simple "push-twist" type plug has been adopted for both the bulb and the resistor. This was accomplished by incorporating a bayonet base on both components.
2. A common receptacle for both the ET-16 and ET-17 coupled with the plug-in resistor and bulb makes it easy to change on the panel without disassembling.
3. The resistor is in series with the bulb, and the ohmic value for the different circuit voltages is designed at 80% of the rated bulb voltage to give it longer life. Changing voltages is easily accomplished by changing the series resistor. (See listed tables for the proper resistor).
4. A short circuit plug is available when a series resistor is not required or if an external resistor is to be used.
5. Standard GE extra-long-life bulbs are specified for all lamps. The ET-16 uses GE Cat. No. 1819 for the 24 DC lamp and GE Cat. No. 1835 for the balance of the ratings. ET-17 uses GE Cat. No. B1A.
6. Terminals are readily available. They are designed for either AMP "FASTON" type connectors, solder, or screws.
7. Nine basic color caps designed for maximum visibility are available for ET-16: Translucent-red, green, yellow, white. Transparent-amber, red, green, blue, and clear.

   ET-17: Because of the special properties of neon, only amber, transparent red, and clear lenses are suitable.

   The color caps have a knurled OUTSIDE DIAMETER FOR EASY REMOVAL.
8. The ET-16 is also available for dim bright applications.
9. When special voltages or resistance is required other than those listed, a special lamp may be ordered with the proper design, or designated series resistor.
10. A two inch insulating washer is supplied with each indicating light. It should be mounted on the inside of the panel as illustrated in Figs. 2,3,and 4. The function of this washer is to provide additional insulation between the terminal and ground (panel)if a surge were to be induced on one of the potential leads.

    If a bulb other than those listed above is required, the lamp will be furnished less the bulb.

    Listed tables give some of the specials made available.

RATINGS

Resistors	ET-16	12.5 Watts
	ET-17	1 Watt

BULB	DESIGN VOLTAGE	DESIGN AMPS	CANDLE POWER	AVERAGE LIFE (HOURS)
1819	28	.04A	Approx. .34	2500
1835	55	.05A	Approx. 1.1	5000
B1A	105-125	.3 MA	-	15,000

CONNECTIONS

See Figure 1A and 1B for typical tell-tale and dim-bright connections.

RECOMMENDED PANEL ASSEMBLY

Thread the pal nut against the shoulder of the receptable. Install the two inch insulating washer on the front of the receptacle against the pal nut. Insert the receptacle thru the panel and thread escutcheon nut against panel. Install color cap; hand tighten (do not force). Turn escutcheon nut back up against color cap, then back off 1/2 to 3/4 turn (recommend 3/4 turn) to give at least 1/64 inch clearance but not more than 1/32 inch clearance between color cap and escutcheon nut (for up to 3/16 inch panel). For 1/4 inch panel, color cap will be flush with escutcheon nut. Tighten the pal nut against panel to 10-12 inch-pounds torque.

TABLE 1

ET-16 - INDICATING LAMP

CIRCUIT VOLTAGE			CAT. NO. (INCLUDES LAMP, COLOR CAP, & RESISTOR	RESISTOR 0165A7844		BULB GE CAT. NO	RECEPTACLE	COLOR CAP †	CARTON	OUTLINE
RATED	MIN.	MAX.		PART NO.	OHMIC VALUE					
24 D-c	22	28	0116B6708G1	1	10	1819	0116B6709G1	SEE ORDERING TABLE 1	0165A9257P1	0165A7859
48 D-c	44	56	0116B6708G2	2	200					
125 D-c	110	140	0116B6708G3	3	2000					
250 D-c	220	280	0116B6708G4	4	5100	1835				
120 A-c	95	130	0116B6708G5	5	1900					
240 A-c	195	260	0116B6708G6	6	4800					

TABLE 2

ET-16 - FOR DIM-BRIGHT APPLICATION

CIRCUIT VOLTAGE			CAT. NO* (INCLUDES LAMP, COLOR CAP, AND RESISTOR)	RESISTOR 0165A9217			BULB GE CAT. NO.	RECEPTACLE	COLOR CAP †	CARTON	OUTLINE
RATED	MIN.	MAX.		PART NO.	RESISTANCE OHMS						
					TOTAL	TAP					
48 D-c	44	56	0127B8108G1	1	450	50	1835	0116B6709 G3	SEE ORDERING TABLE 1	0165A9257 P2	0165A9216
125 D-c	110	140	0127B8108G2	2	2550	1700					
250 D-c	220	280	0127B8108G3	3	6000	4400					
120 A-c	95	130	0127B8108G4	4	2450	1600					
240 A-c	195	260	0127B8108G5	5	5700	4200					

TABLE 3

ET-17-INDICATING LAMP

VOLTAGE RANGE A-c/D-c	CAT. NO.* (INCLUDES LAMP, COLOR CAP, AND RESISTOR)	RESISTOR 0165A7956		BULB GE CAT. NO.	RECEPTACLE	COLOR CAP †	CARTON	OUTLINE
		PART NO.	OHMIC VALUE					
110-139	0116B6734G1	1	200-K	B1A	0116B6709G1	SEE ORDERING TABLE 2	0165A9257P3	0165A7955
140-219	0116B6734G2	2	560 K					
220-299	0116B6734G3	3	750 K					
300-374	0116B6734G4	4	1 MEG					
375-449	0116B6734G5	5	1.2 MEG					
450-600	0116B6734G6	6	1.6 MEG					

† Specify color cap from Table 6 or 7.

TABLE 4

ET-16 SPECIAL 127B8177

INDICATING LAMP COMPLETE

GROUP NUMBER*	VOLTS	1 REQ'D. OF GR. OR PT.NO. LISTED BELOW					COLOR CAP	CARTON	OUTLINE
		RESISTOR				BULB G.E. CAT. NO.			
		RECEPTACLE	DRG. NO.	PART NO.	OHMIC VALUE				
1	70	0116B6709 G-1	0165A7844	7	750 Ω	1835	**	0165A9257 P-1	0165A7859
2	17			8	50 Ω	756	SEE ORDERING TABLE		
3	140			9	2500 Ω	NONE			
4	220			10	4300 Ω	1835			
5	32			2	200 Ω	1819			
6	125			11	3300 Ω	1835			
7	277			12	5900 Ω	1835			
8	140			9	2500 Ω	1835			
9	130			13	2300 Ω	1835			

**756 Bulb Furnished By Customer

TABLE 5

ET-17 SPECIAL 128B1654

INDICATING LAMP COMPLETE

GROUP NO **	VOLTS	1 REQ'D. OF GR. OR PT. NO LISTED BELOW							OUTLINE
		RECEPTACLE	RESISTOR			BULB G.E. CAT. NO.	COLOR CAP	CARTON	
			DRG. NO.	PART NO.	OHMIC VALUE				
1	210-250 AC/DC	0116B6709GR-1	0165A7956	1	56K	NE51H**	SEE ORDERING TABLE	0165A9257	0165A7955
2	67-120 AC			8	80K	NE51 OR B1A			

** NE51H BULB
Furnished By Customer

TABLE 6

COLOR CAP

CAT. NO.	COLOR CAP	
	COLOR	CAT. NO.
0116B6708G	NONE	NONE
0116B6708G*C	CLEARπ	208A3768P1
0116B6708G*R	RED Ø	208A3768P2
0116B6708G*G	GREEN Ø	208A3768P3
0116B6708G*Y	YELLOW Ø	208A3768P4
0116B6708G*W	WHITE Ø	208A3768P5
0116B6708G*B	BLUE π	208A3768P6
0116B6708G*A	AMBER π	208A3768P7
0116B6708G*D	GREEN π	208A3768P8
0116B6708G*E	RED π	208A3768P9

ORDERING TABLE 7

COLOR CAP

CAT. NO.	COLOR CAP	
	COLOR	CAT. NO.
0116B6734G*	NONE	NONE
0116B6734G*C	CLEAR	208A3768P1
0116B6734G*E	REDπ	208A3768P9
0116B6734G*A	AMBER	208A3768P7

*=Group No. per Voltage Selected
For Other Voltages Refer to Company
Group No. with No. Suffix=Color Cap Omitted
πTransparent
∅ Translucent

HOW TO ORDER

Order by complete Cat. No. and specify color cap.

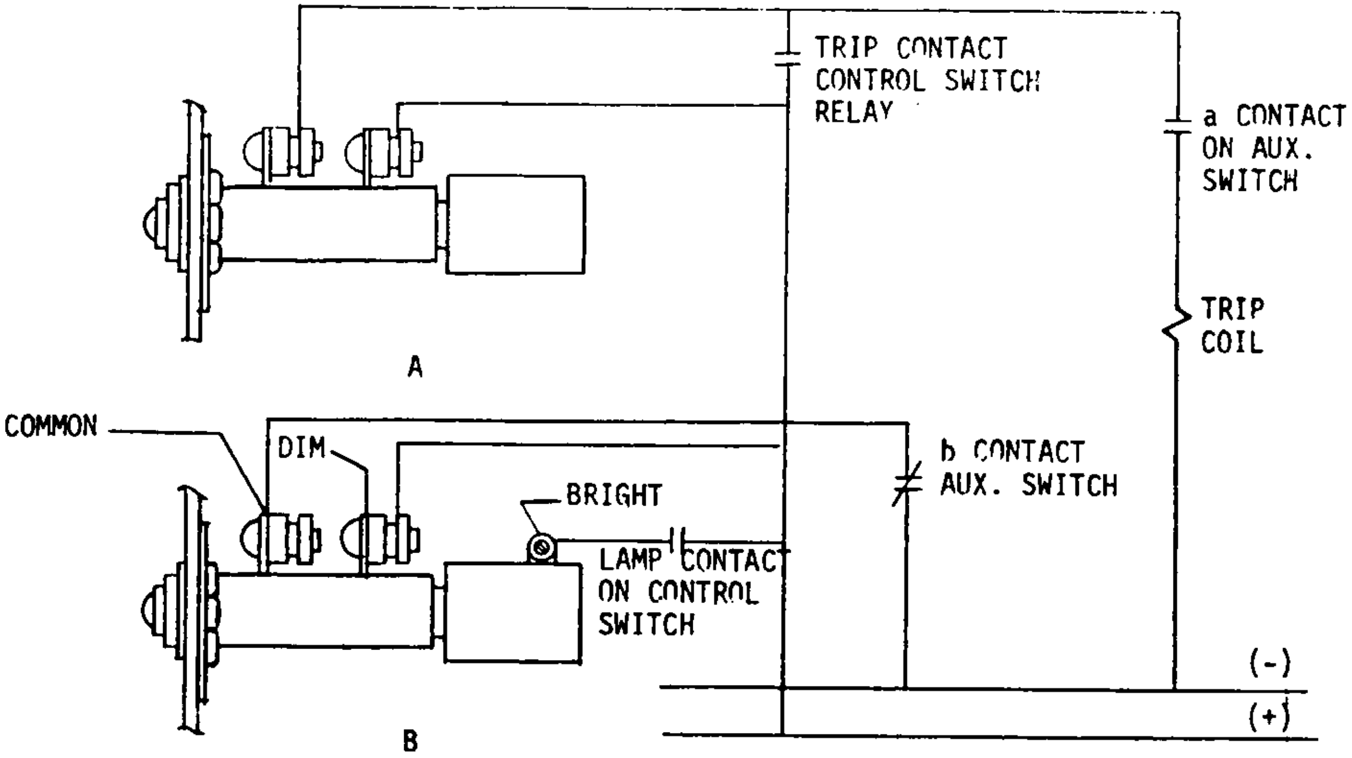


FIG A - SHOWS A TELL-TALE CIRCUIT FOR A CIRCUIT BREAKER CLOSE INDICATION. WHEN THE BREAKER IS CLOSED, THE LIGHTED (RED) LAMP SHOWS NOT ONLY THE BREAKER POSITION, BUT ALSO THAT THE TRIP CIRCUIT IS COMPLETE.

FIG B - FOR CIRCUIT BREAKER OPEN INDICATION, THE DIM-BRIGHT CONNECTION IS OFTEN DESIRABLE, ESPECIALLY WHEN A LARGE NUMBER OF LAMPS ARE LOCATED ON ONE PANEL. A LAMP UNIT WITH TAPPED RESISTOR IS REQUIRED, TOGETHER WITH A CONTROL SWITCH HAVING A LAMP CONTACT WHICH REMAINS CLOSED IN THE NORMAL POSITION, EXCEPT AFTER THE SWITCH HAS BEEN TURNED TO THE TRIP POSITION. A WHITE COLOR CAP ON THE LAMP IS CUSTOMARY. WHEN THE BREAKER IS TRIPPED WITH THE CONTROL SWITCH, THE SWITCH CONTACT IS OPENED, AND THE LAMP GLOWS WITH LOW BRILLIANCY. IF THE BREAKER IS TRIPPED AUTOMATICALLY, THE CONTROL SWITCH CONTACT SHORT-CIRCUITS PART OF THE LAMP RESISTOR SO THE LAMP GLOWS BRIGHTLY, AND THE NON-MANUAL OPERATION CAN BE EASILY LOCATED ON THE PANEL.

FIG. 1 (0246A3685-1) Typical Tell-Tale And Dim-bright Connec

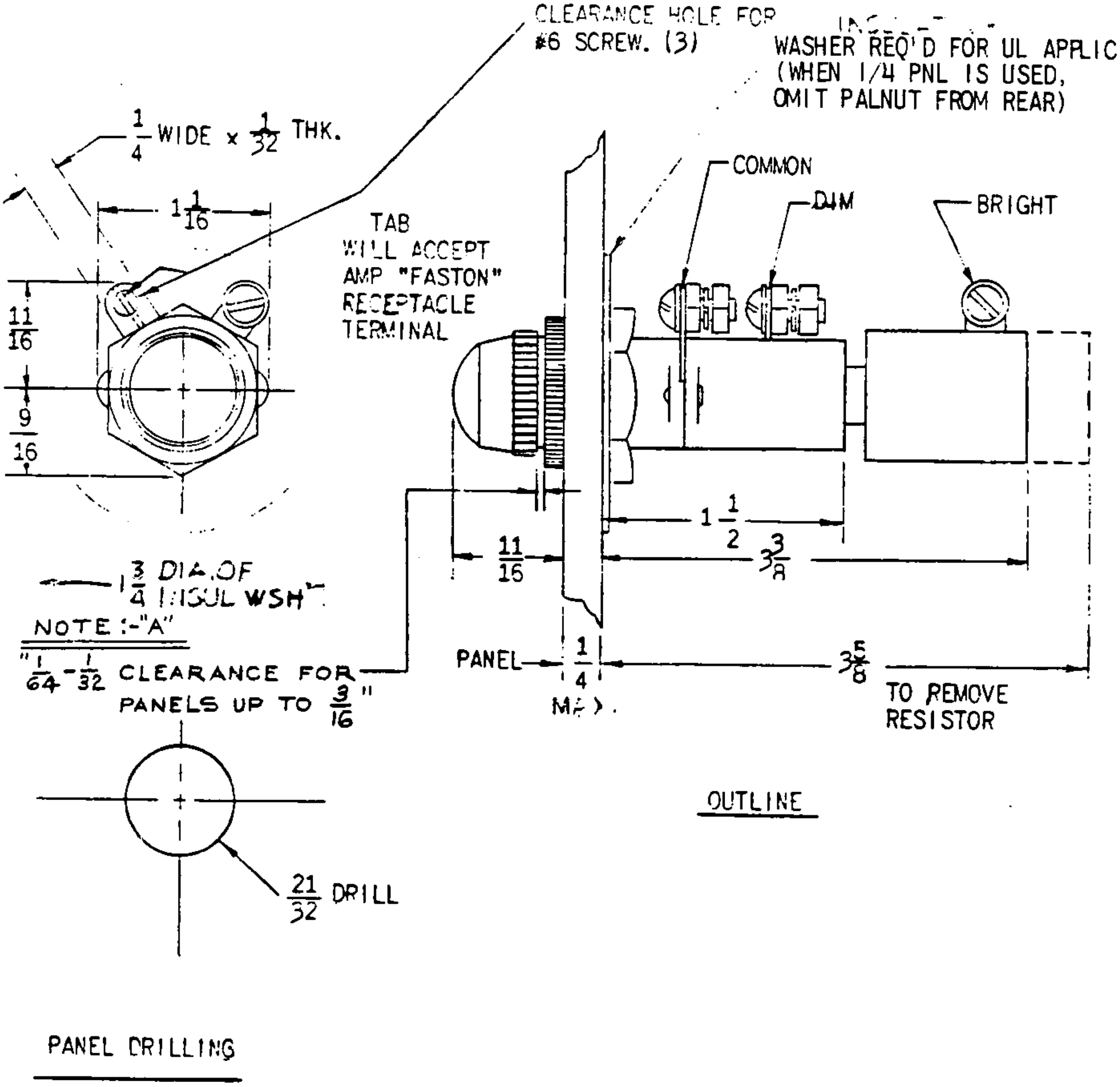
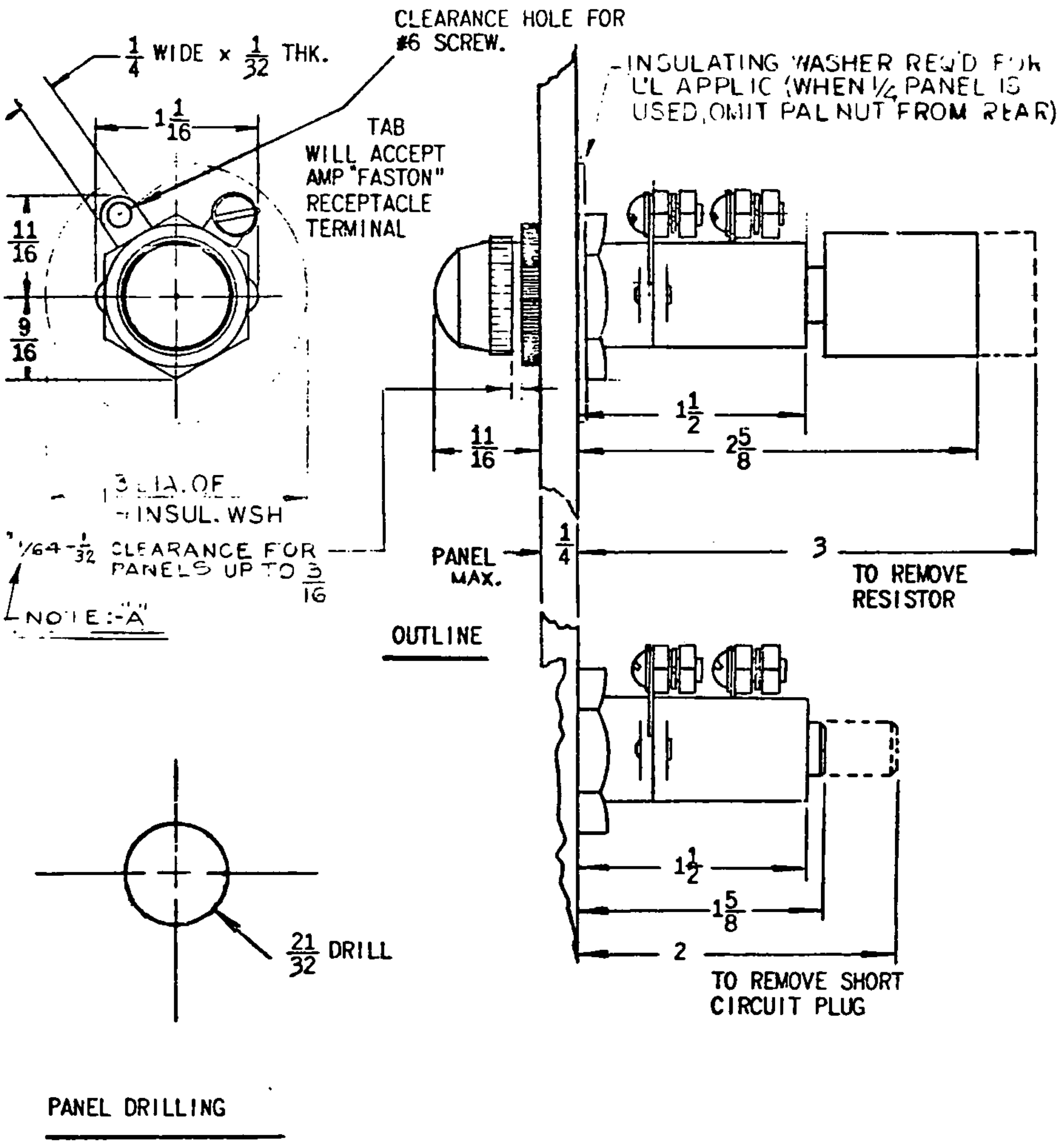


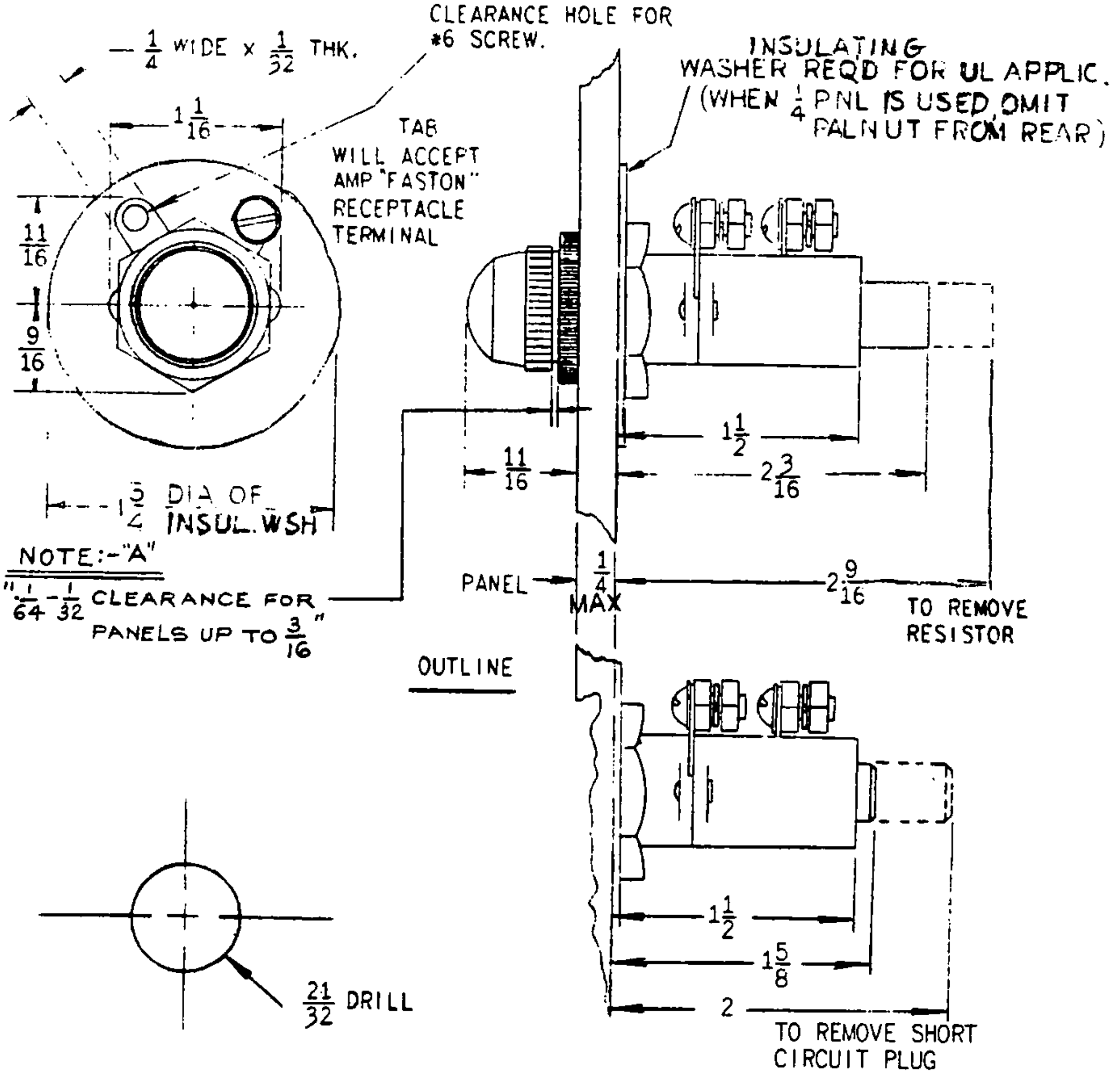
FIG.2 (0165A9216-3) Outline And Panel Drilling For Type ET-16 Indicating Lamp With Tap Resistor For Dim Bright Operations



OUTLINE

PANEL DRILLING

FIG.3 (0165A7859-6) Outline And Panel Drilling For Type ET-16 Indicating Lamp



PANEL DRILLING

FIG.4 (0165A7955-6) Outline And Panel Drilling For Neon Indicating Lamp Type ET-17

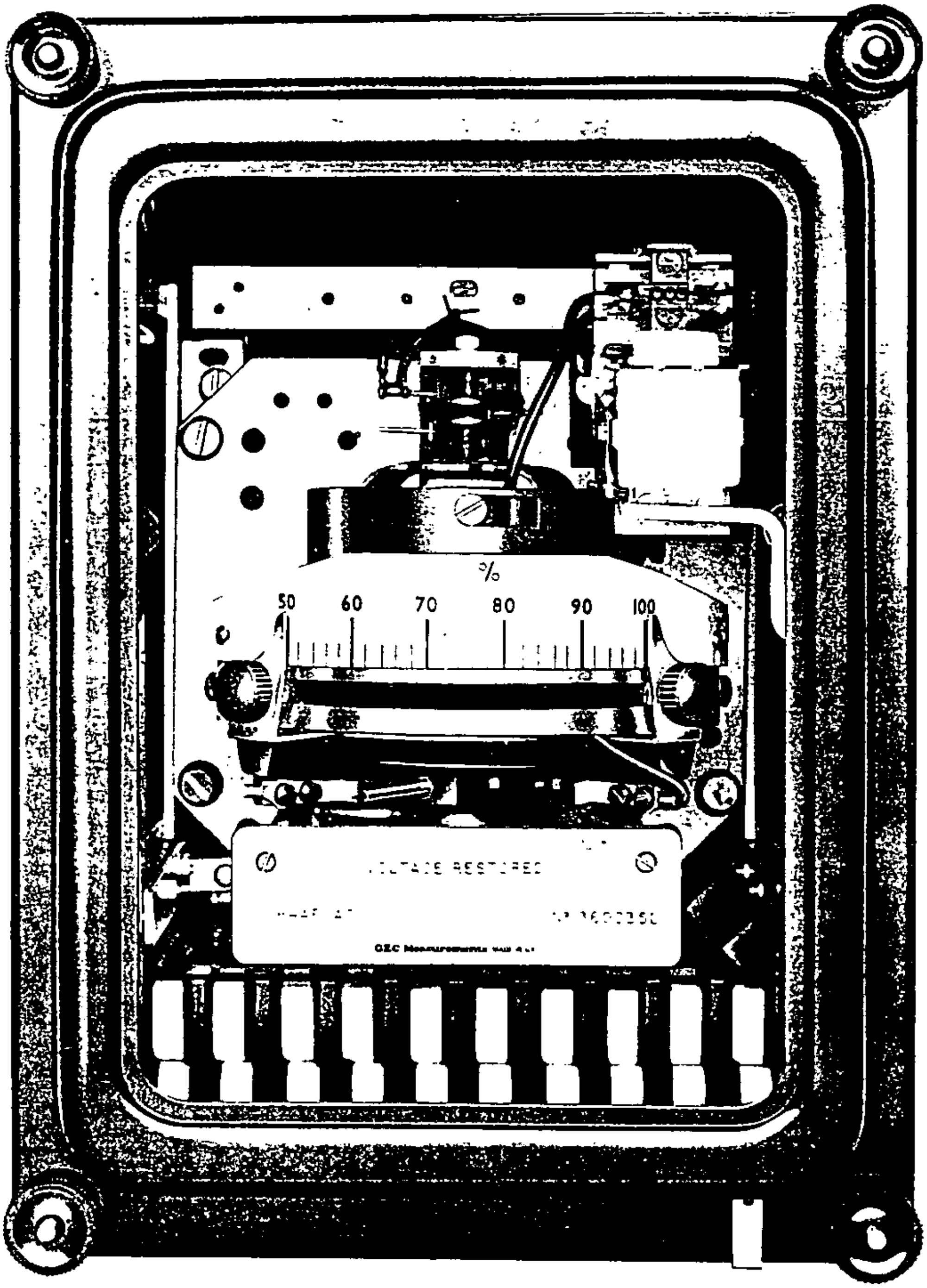
GENERAL ELECTRIC COMPANY
POWER SYSTEMS MANAGEMENT BUSINESS DEPT.
MALVERN, PA 19355

GENERAL ELECTRIC

Measurements

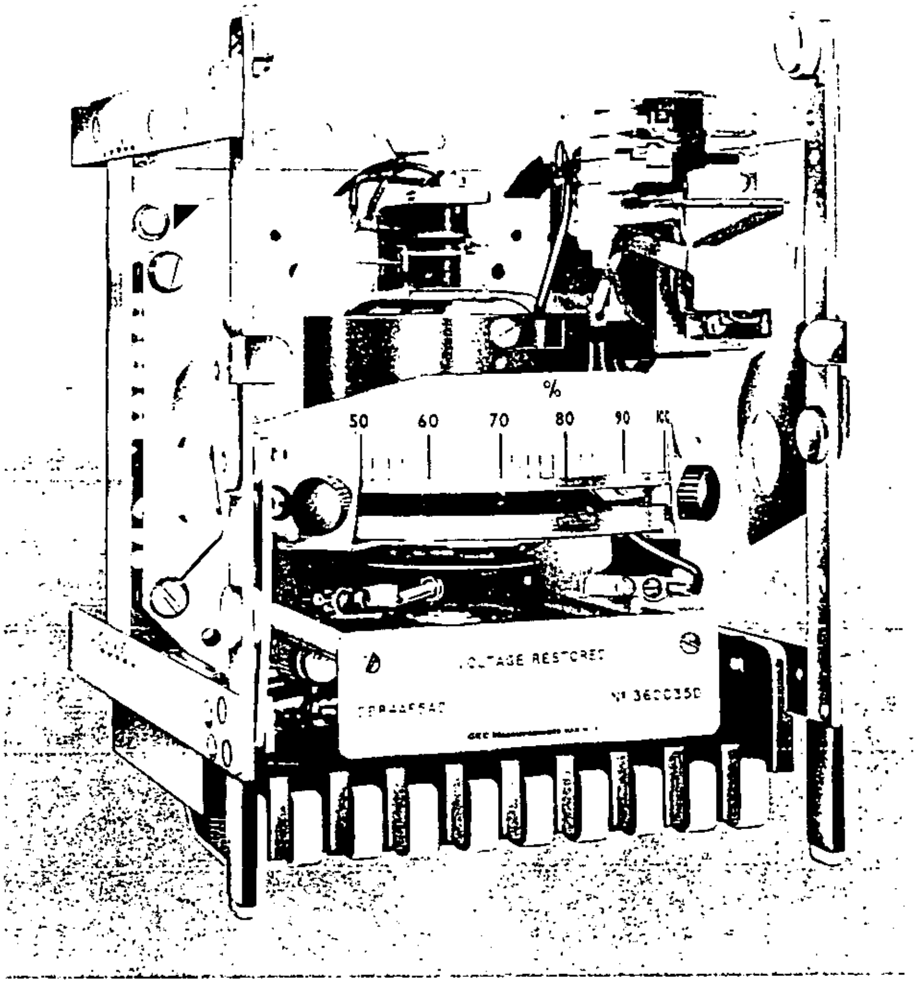
Sensitive Moving Coil Relays

Types DBA4 and DBB4



Types
DBA4 and DBB4

- High sensitivity and torque
- High damping
- Drop-off/pick-up ratio 97%
- Low burden
- Bi-directional operation (type DBB4)
- Approved by British Electricity Supply Authorities



APPLICATION

The small energy consumption of the relay movement permits many applications that would not be feasible with simple electro-magnetic relays; the inherent directional property and inverse time-lag are other valuable features.

The versatility of these relays is indicated by these typical applications:

Overcurrent and/or reverse current protection of d.c. systems. Usually by means of an auxiliary heavy current shunt.

Overvoltage and/or undervoltage protection of d.c. systems.

A.c. current or voltage measurement by means of internal rectifier with, for high currents or voltages, auxiliary measuring transformers.

By means of auxiliary C.T.'s and rectifiers and other components, the relays can be applied to a wide range of protection or control schemes for a.c. systems.

CONSTRUCTION

The basic design of the relay follows the conventional d'Arsonval principle, in that it consists of a moving coil rotating in a radial magnetic field. But it must not be confused with instrument movements fitted with contacts which in general are unsuitable for any but the simplest duty of closing a low-rated alarm circuit.

Moving coil damping

Generally the coil is wound on an aluminium former which provides efficient damping due to the eddy currents induced in it when it moves in the magnetic field. When extra heavy damping is required, a copper former is used and still more damping can be obtained if an internal shunt is used across the coil.

Sensitivity

Alternative control springs providing standard or approximately double or half standard torque can be fitted.

Moving contact

The moving contact shown in Figures 1 and 2 is designed especially to provide the resilience necessary to ensure satisfactory contact making with low available forces. A relay of this type gives a deflection proportional to the applied current and with a current of setting value contact make will be achieved but the entire operating torque will be absorbed by the control spring leaving no margin of force for contact pressure. It follows that for currents only slightly above setting value, contact making is relatively poor and a highly resilient contact is necessary. At the same time it must be protected from mechanical damage arising from the high accelerating force generated when the relay is subject to the large current related to heavy fault conditions. This has been successfully achieved by coil stops and by making the contact from flexible silver alloy wire, pressed and soldered into a screwed brass mount. A duralamin tube, pressed into the same mount, surrounds the silver contact wire over the majority of its length. The duralamin tube does not carry current.

The screwed brass mount is fitted to an insulator carried on the movement shaft and connection to the moving contact is made by a silver ligament which is screened on each side by mica insulators.

Pivots and bearings

The movement is supported on precision ground 'V' shaped hardened steel pivots, mounted in spring-loaded jewelled bearings, to prevent damage arising from shock or vibration. Vertical mounting of the movement also reduces pivot friction to a minimum.

Movement stirrup

The die-cast stirrup embodies accurate locations for the movement bearings and permanent magnet, ensuring concentricity of the movement. A die-cast clamping piece, similar in shape to the centre section of the stirrup, locates on the magnet centre pole, the complete assembly, comprising stirrup, magnet and clamping piece is then secured in the mild steel tube by two grub screws.

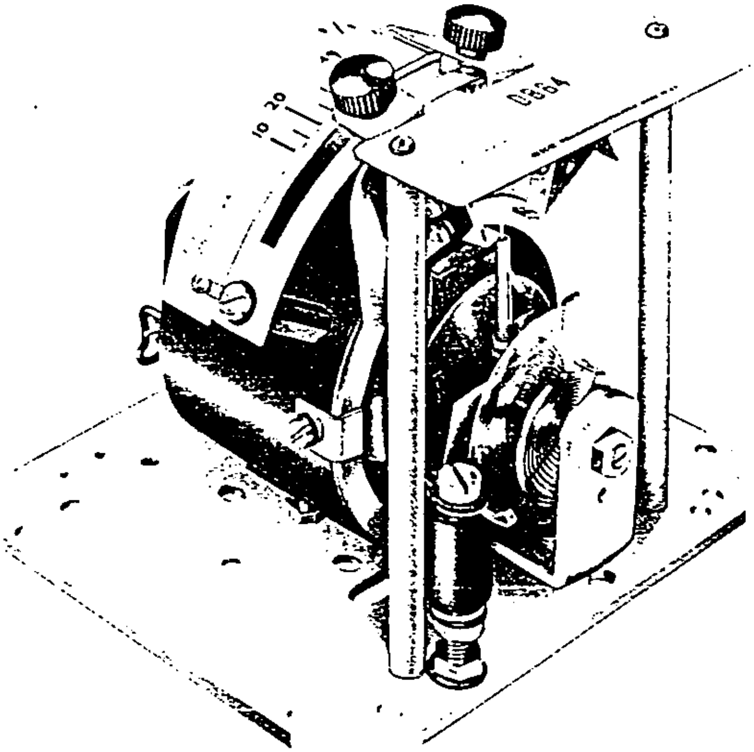
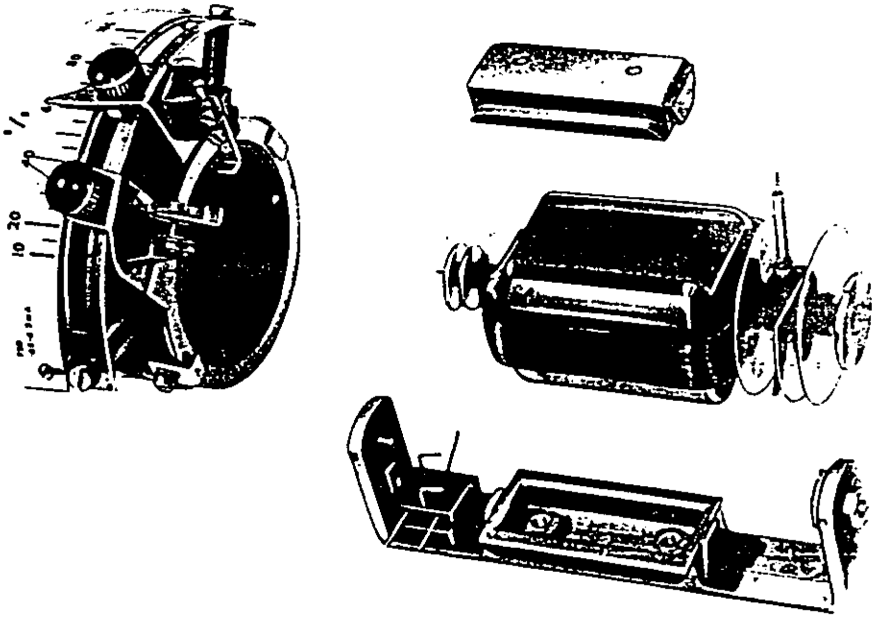


Figure 1 Relay type DBB4 out of case



Magnet assembly

The permanent magnet, consisting of a rectangular block of a high-energy type of magnet steel, is positioned within the moving coil and has mild steel pole pieces so shaped that the whole forms a cylindrical cross-section, providing a uniform magnetic field over the effective angular travel of the coil. To achieve maximum field strength the magnet is magnetised 'in situ' at a stage after assembly of the movement.

A mild steel tube surrounds the magnetic circuit, reducing external flux leakage to a minimum.

The result is a magnetic circuit in which all flux emanating radially from the magnet is usefully employed.

Adjustable quadrants

Two adjustable quadrants are located on a shoulder on the end of the mild steel magnet tube. The quadrants combine the functions of contact carriers and coil stops, the position of the coil stops being such that they permit a constant contact wipe irrespective of the contact setting. Depending upon the application, contacts are fitted to either one or both of the quadrants. When only one contact is fitted, the other quadrant may be used as an adjustable back-stop for the coil, restricting the movement of the coil from the 'contact closed' position by any desired amount. Each of the adjustable quadrants have pointers which register over a common scale. Pointers may be locked in any desired position by a knurled clamping screw.

OPERATION

Circuit description

A typical arrangement of the type DBA4 relay is shown in Figure 3. The measuring element contact may be connected directly to terminals, or used to operate an auxiliary follower element type VAA, mounted internally. For measurement of a.c. inputs, a bridge rectifier is included in the circuit.

The circuit arrangement for the type DBB4 relay shown in Figure 4 is basically similar but commonly provides additional contacts for operation in either direction.

Seal-in feature

When required, the left hand adjustable contact can also be used to provide a 'seal-in' feature as shown in Figure 5. This arrangement can be used to produce an adjustable drop-off, pick-up setting ratio and also improve mechanical stability. One contact of the auxiliary element is used to seal-in the element as soon as the measuring element has operated.

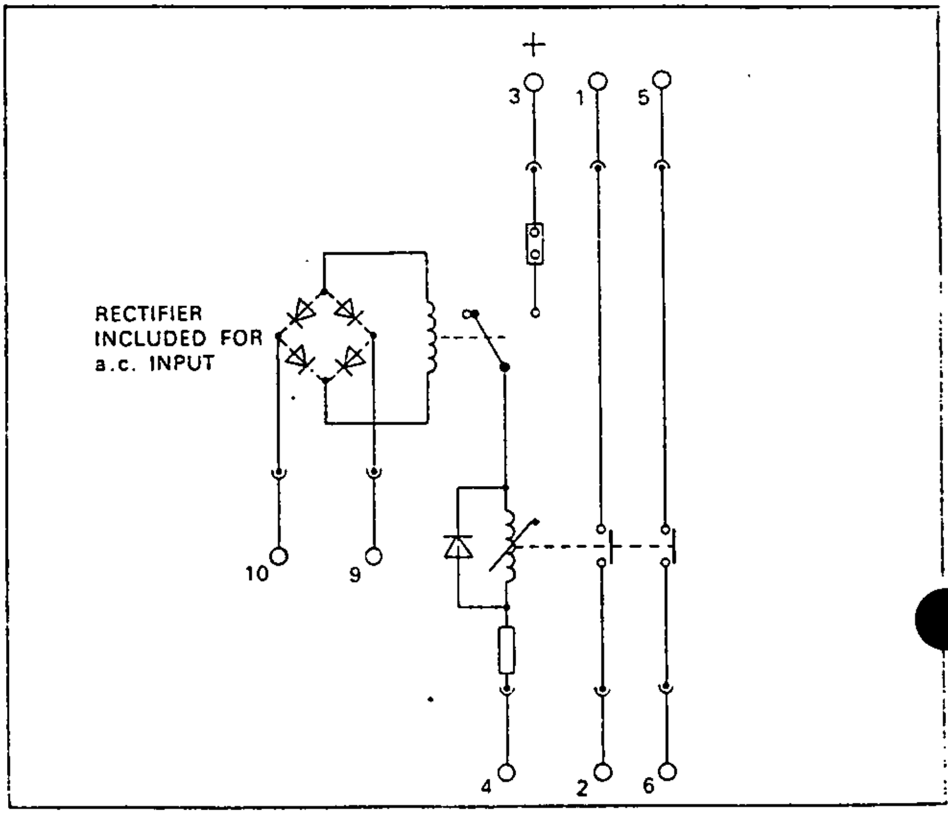


Figure 3 DBA4 Relay with auxiliary element

The auxiliary element will then remain energised until the measured quantity has reduced to the point where the left hand contact closes, short circuiting the auxiliary element coil. The auxiliary element then resets, opening the sealing circuit.

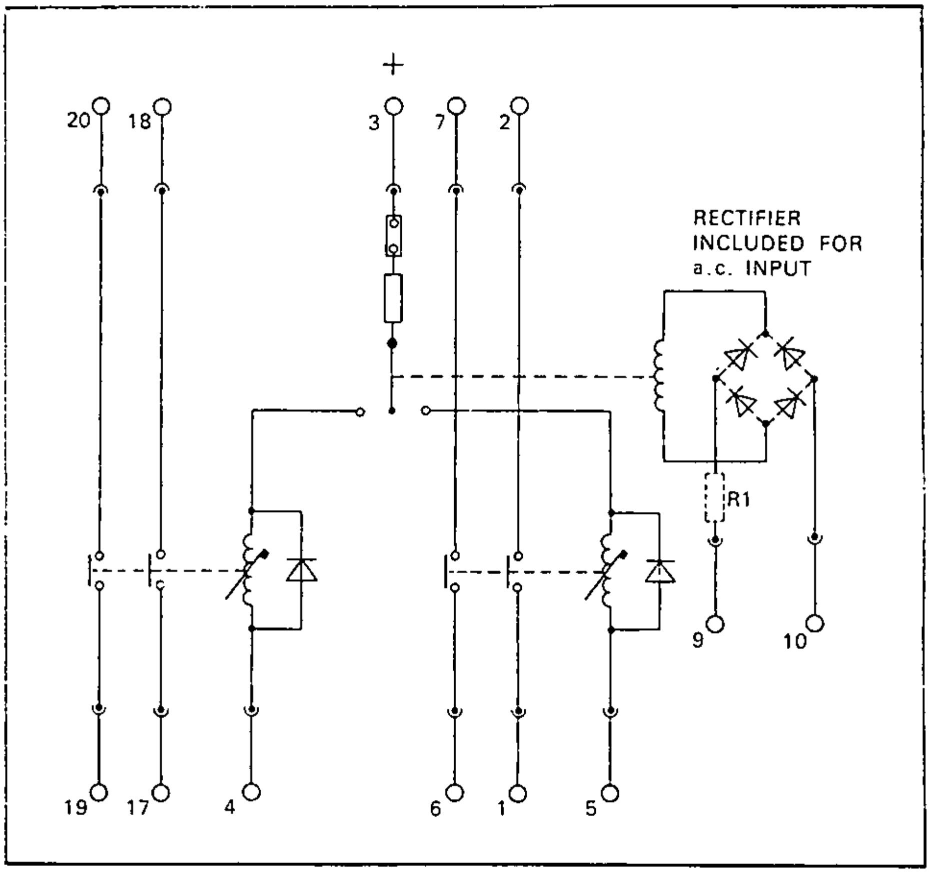


Figure 4 DBB4 RELAY WITH AUXILIARY ELEMENTS

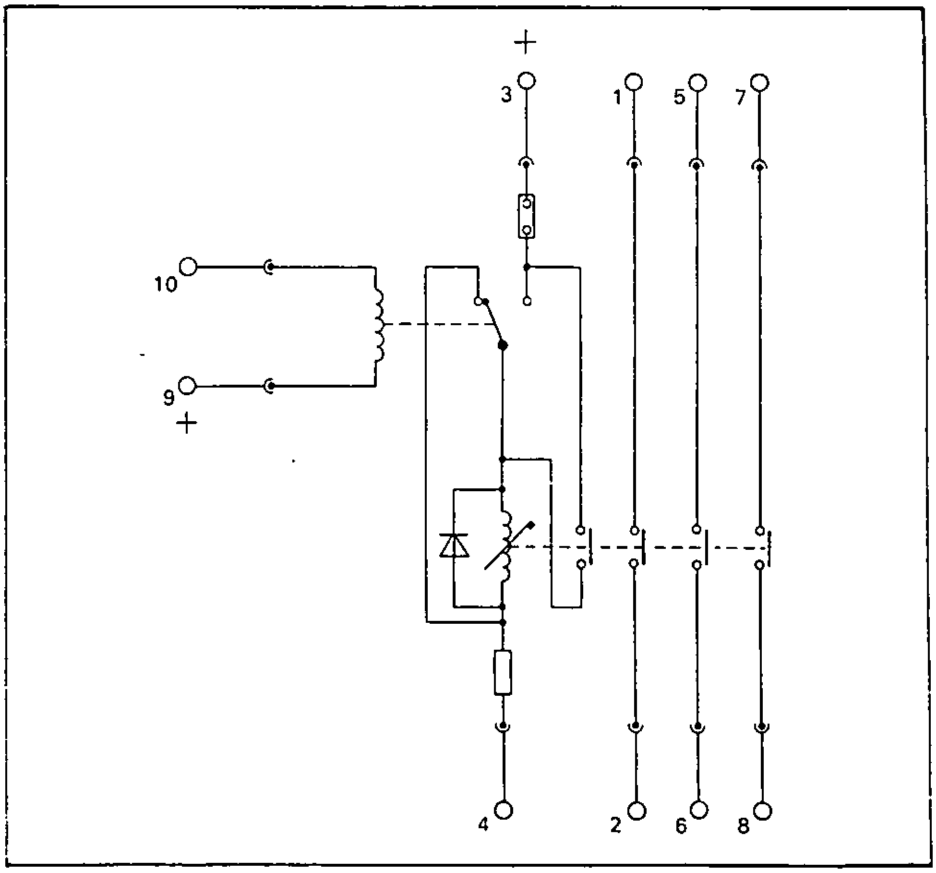


Figure 5 DBB4 RELAY WITH SEAL IN AUXILIARY ELEMENT

Operating time characteristics

The inherent inverse time characteristic is illustrated in curves Figure 6 and Figure 7, which show the effect on operating times of different contact settings and multiples of current settings.

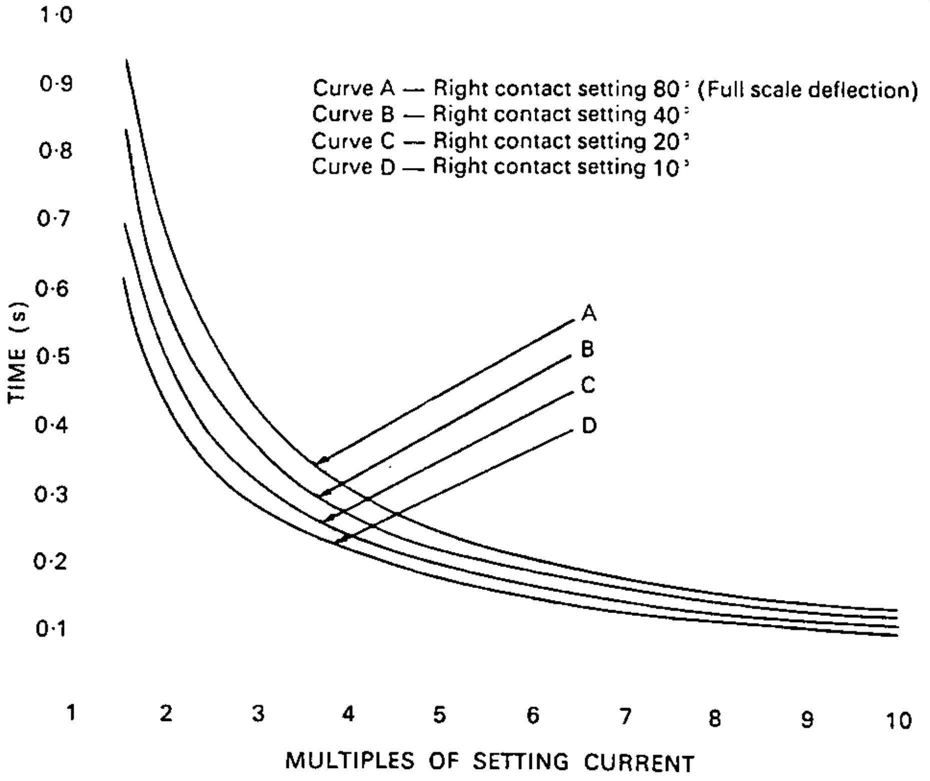
Figure 6 depicts conditions as operating from a normal free zero to varying settings of the right contact, whilst Figure 7 shows conditions as operating from varying settings of the left contact (that is, with a set up zero) to a constant maximum setting of the right contact. An infinite variety of curves is possible between these limits. It should be noted that the curves are typical only for a relay fitted with a standard torque spring and a standard aluminium coil former, no undertaking is given in manufacture to reproduce any particular curve.

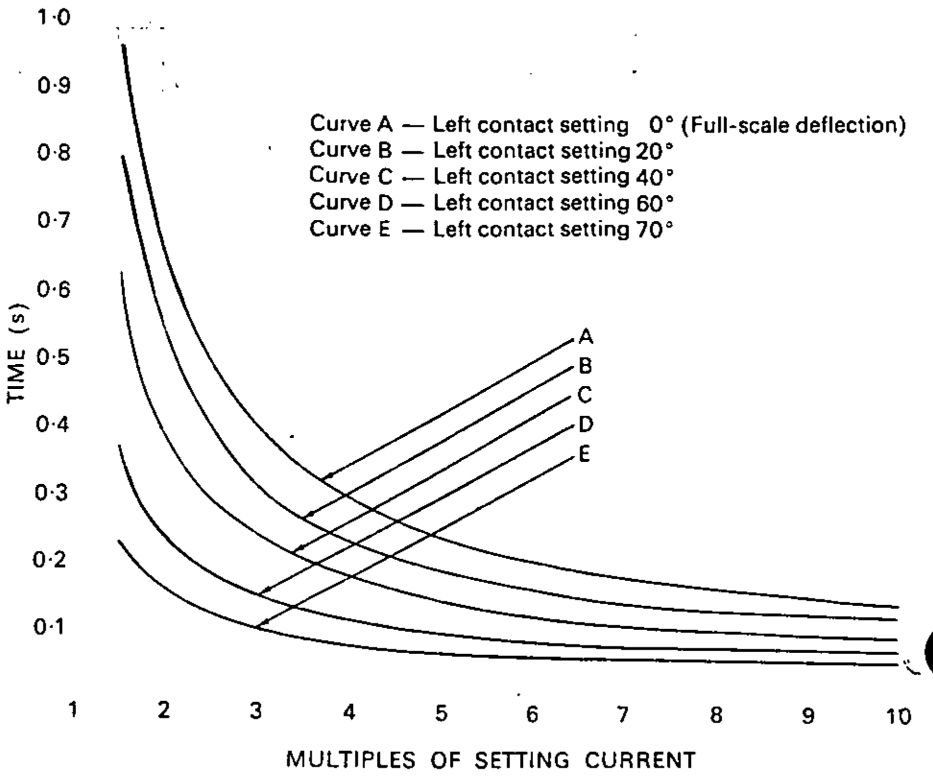
A considerable range of operating times is obtainable by suitable settings of the relay contacts to modify the angle of movement, and/or by choosing a nominal operating current exceeding the relay setting.

The relay may be used to fulfil short-term timing functions, provided the operating coil is supplied from a constant source and the appropriate settings are used, see Figure 6 and Figure 7.

By suitable combinations of short travel and the appropriate degree of over-setting, operating times as quoted in BS.142 : 1966 for instantaneous relays may be obtained.

NOTE: The asymptotic regions of the curves have been purposely omitted since it is considered that timings in these regions are too indeterminate to be of much value.





Operating characteristics

	Shunt-operated (75 millivolt) (standard torque)	Voltage operated (standard torque)	High sensitivity voltage operated (half torque)	Thermo-couple operated (half torque)
Coil resistance (ohms)	0·2	65	245	9·5
Nominal full-scale current (mA)	60	2·5	0·5	2·4
Milliamps per degree deflection	0·75	0·031	0·00625	0·03
*Nominal full-scale millivolts	12	—	—	22·8
*Millivolts per degree deflection	0·15	—	—	0·285
Nominal full-scale burden (microwatts)	Coil only 720	410	61	55
†Microwatts for 1° deflection	Coil only 0·11	0·064	0·01	0·009
Maximum continuous current (amp)	1·5 (i.e. 25× maximum setting)	0·175 (i.e. 70× maximum setting)	0·092 (i.e. 184× maximum setting)	0·45 (i.e. 180× maximum setting)

* Uncompensated for temperature coefficient of resistance.

† Multiply by the square of deflection in degrees.

Measuring element contact ratings

Make and carry momentarily	Carry continuously	Break
500VA, a.c. or d.c. subject to a maxima of 600V and 3 A	1 A a.c. or d.c.	100VA, a.c. subject to a maxima of 250V and 1 A 30 Watts d.c. (non-inductive) subject to a maxima of 250V and 1 A

When intended for primary tripping, relays are supplied with an auxiliary unit fitted with higher capacity contacts.

Auxiliary elements

A type VAA auxiliary attracted armature unit may be mounted with the relay in a size 1D drawout case, or up to three attracted armature units can be housed with the relay in a size 1½D drawout case.

Two pairs of contacts with any combination of normally open or normally closed are generally fitted, but this may be extended to suit customers' requirements. Changeover contact arrangements are also available.

Standard contacts are of a silver/copper alloy, shaped and positioned to ensure a very reliable, low-resistance contact. Special silver/cadmium alloy tips with anti-welding properties suitable for carrying heavy current for short periods can also be supplied. Details of ratings will be supplied on request.

Contact ratings

Type of Contact	Current	Make and carry continuously	Make and carry for 3 seconds	Break
Standard	a.c.	1250 VA with maxima of 5A and 660V	7500 VA with maxima of 30A and 660V	1250 VA with maxima of 5A and 660V
	d.c.	1250 W with maxima of 5A and 660V	7500 W with maxima of 30A and 660V	100 W (resistive) 50 W (inductive) with maxima of 5A and 660V

Operation indicator

A hand re-set operation indicator is fitted as standard on the auxiliary unit.

Burden of auxiliary unit –
type VAA (at 125V d.c.)

coil 2·1W

series resistor 5·4W

Insulation

The relay will withstand 5kV, 50Hz, for 1 minute between each pair of the following groups:

(a) Measuring element circuit.

(b) Auxiliary element coil and contact circuits.

(c) Relay case (earth).

The relay will also withstand 2kV, 50Hz, for 1 minute between any pair of the following groups:

(a) Auxiliary unit coil circuit.

(b) Output contact circuits.

(c) Relay case.

PARTICULARS REQUIRED WITH ORDERS

Please state:

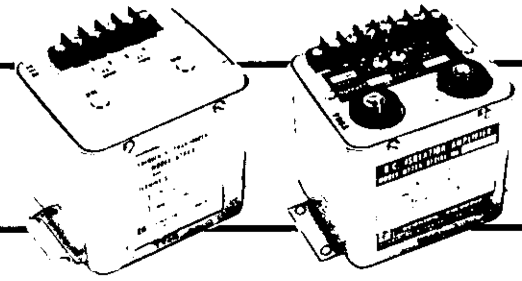
1 Type of relay (DBA4 or DBB4).
2 Application.
3 Supply system details.
4 If voltage or current operated.
5 If shunt operated, give shunt data and particulars of leads if other than standard 4ft (1·2 metres).
6 Scale marking and setting range.
7 If auxiliary element is required
   (a) Number and arrangement of contacts;
   (b) Trip circuit voltage and contact rating required.
8 Is an operation indicator required? If so state if shunt or series operated.
9 Type of mounting: flush or projecting.
10 Panel thickness.
11 Any other relevant information.

GEC Measurements The General Electric Company Limited of England

St. Leonards Works Stafford ST17 4LX England
Telephone: 0785 3251 Telex: 36240 Cables: Measurements Stafford Telex

Publication R-5257 A

EXCELTRONIC™



FREQUENCY TRANSDUCERS

Models 6281B, 6283B, 6284B

DESCRIPTION

Scientific Columbus Frequency Transducers develop a DC output signal which is proportional to input frequency.

These transducers have an expanded scale output. A variety of calibrations may be ordered or the user may calibrate the transducer at the installation site to meet specific requirements.

These transducers feature the exceptional Scientific Columbus constant current output. This means, for a given input, no adjustment is necessary to compensate for various output signal loop characteristics.

Series components and devices such as indicators, recorders, resistors for alarms and analog-to-digital pick-off points can be added to the output signal circuit without recalibrating these transducers. Filtering is also included, which simplifies matching these units to fast response devices.

SPECIFICATIONS

	6281B	**6283B**	**6284B**
Input Voltage	120 V	120 V	120 V
Overload	150 V	150 V	150 V
Frequency Range	45-55 Hz	375-425 Hz	55-65 Hz
Output	0-1 ma into 0-10K ohms	0-1 ma into 0-10K ohms	0-1 ma into 0-10K ohms
Accuracy	± 0.02% of Center frequency at 25° C	± 0.02% of Center frequency at 25° C	± 0.02% of Center frequency at 25° C
Ambient Temperature Effect on Accuracy	± 0.0025%/° C Max.	± 0.0025%/° C Max.	± 0.0025%/° C Max.
Adjustments	Zero, Span	Zero, Span	Zero, Span
Burden	4VA	4VA	4VA
Ripple	1% maximum output peak	1% maximum output peak	1% maximum output peak
Temperature Range	− 20° C to + 60° C	− 20° C to + 60° C	− 20° C to + 60° C
Response	0.4 sec. to 99% of final value	0.4 sec. to 99% of final value	0.4 sec. to 99% of final value

Connections see page 49, Connection 49E Packaging see page 47 Style II Case

SHUNT/ISOLATION/ AMPLIFIER **Model 6271A**

DESCRIPTION

The Model 6271A Shunt Amplifier is a linear amplifier designed to amplify DC shunt millivolt signals or D.C. voltages from 50 MV to 1000 V D.C., and provides *complete isolation* of the input signal. A magnetic amplifier is used in the input circuit to isolate the input from all other circuits and grounds. The input is tested at *4000 volts D.C.* for one minute to insure that no breakdown will occur when connected to shunts operating at high voltage levels above ground. The output circuit is a hybrid amplifier operating in the transconductance mode to provide a constant current output. Load resistance variations from 0-10K have less than 0.1% effect on the output current. This makes the amplifier an ideal device for telemetering, scaling, recording applications or matching to tone transmitters or A to D converters. The output is also filtered, thus making expensive filtering unnecessary.

A 20 turn zero and gain adjustment is provided and is accessible through the top cover. Large gain changes can be accomplished by changing the auxiliary gain resistor across terminals 3 and 4.

SPECIFICATIONS

Power Requirements	120V 60 Hz ± 10% 10VA (Max.)
Signal Input (nominal)	0 to ± 100 Millivolts
Signal Input Range Options	50 MV to 1000 V D.C.
Input Impedance	5000 ohms/Volt
Output D.C.	0 to ± 1 ma
Load Impedance	Any Load between 0-10K
Accuracy	± 0.5% RO @ 25°C
Temperature Range	− 10° C to + 70° C
Temperature Coefficient	± 0.04% °C
Size	3" x 4⅝" x $4^{7}/_{16}$" High
Packaging	Style II Metal Case

Connections see page 49
Connection 49D

Dimensions see page 47
Style II Case

D.C. AMPLIFIER **Model 6181A**

SPECIFICATIONS

Amplifier Type and Model	DC Instrument Amplifier/6181A
DC Input Limits Max	Current 10µa to 5 ma Voltage 10 mv to 8 Volts
DC Output Limits	Current 10 ma Voltage 8 Volts
Effective Input Impedance	Less than 10 ohms for current input, more than 10 megohms for voltage input
Gain Stability	± 0.5% maximum output*
DC Linearity	± 0.5% of maximum output*

Zero Stability	20µv/° C maximum (5µv/° C typical) referred to input
Response Time	0.1 second or better to reach 99% of final value
Ambient Temperature Range	− 10° C to + 50° C
Duty Cycle	Continuous*
Weight	Approximately 2-1/2 lbs.
Power Requirements	100-130 V, 50-400 Hz, single phase, 5 VA

See Unit Instruction Manual for 4 modes of operation

---

* Within specified ambient temperature range.

* Must fall within input, output and feedback resistance limits listed.

SCIENTIFIC COLUMBUS

AN ESTERLINE COMPANY

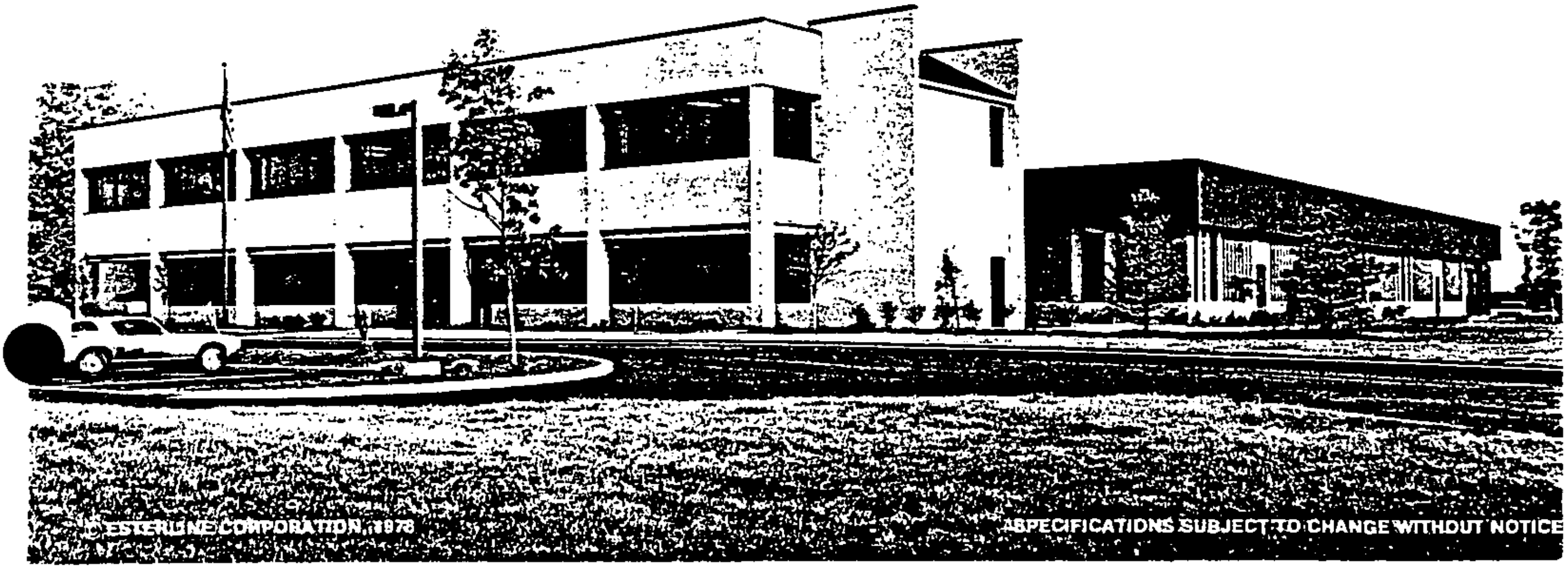
Power Instrumentation Specialists to

ELECTRIC UTILITIES
INDUSTRY
and SYSTEM MANUFACTURERS

Presents

THE DIGILOGICS
THE EXCELTRONICS®
THE JEMS®
THE MICROJOULES
AND RELATED DEVICES

These high accuracy transducers, solid state meters, signal conditioners, test equipment, laboratory and field standards, along with custom designed instrumentation systems are recognized as outstanding contributions to the electrical energy measurement field.



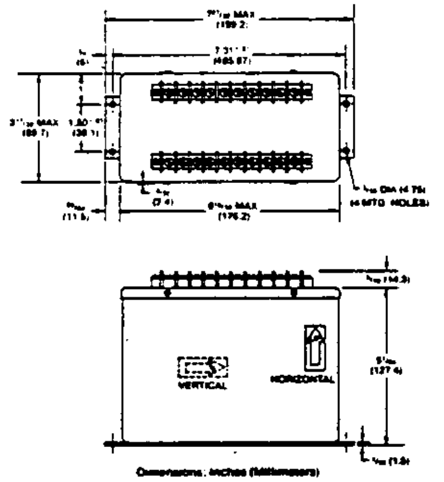
Modifications and Options for Transducers

Modification Description	Applicable Models	Suffix To Model No.	Modified Rating or Description
OUTPUTS			
Calibration			
External Power	Watt, VAR, Watt/VAR	A2	Auxiliary Power required.
Internal Power	Watt, VAR, Watt/VAR	A4, in place of A2	Auxiliary Power not required.
50-200% Cal. Adj. (current)	XL Watt, XL VAR	– 20	0.5-2.0 mA full scale at rated input.
50-200% Cal. Adj. (voltage)	XL Watt, XL VAR	– 21	5-10 Vdc full scale at rated input.
High Accuracy	Volt, Current	A4 (delete A2)	± 0.1% RO accuracy
Certification of Compliance	All models	Use word description	
Traceability to NBS	Watt, VAR, Current, Volt	Use word description	
Sepia Drawings	Connections/Outlines	Use word description	
Scaling Resistors	All models	"Special Calibration"	0.025% wire-wound precision scaling resistors
Seismic Rated	Watt, VAR, Current, Voltage	– S	Test Data Available
INPUTS			
69 Volts (0-90 V)	Watt, VAR	– 0	250 watts (VARs) per element
240 Volts (0-300 Volts)	Watt, VAR	– 1	1000 watts per element
480 Volts (0-600 V)	Watt, VAR	– 2	2000 watts per element
1 Amp	Watt, VAR	– 3	100 watts (VARs) per element
2.5 Amp	Watt, VAR	– 4	250 watts (VARs) per element
7.5 Amp	Watt, VAR	– 11	750 watts (VARs) per element
10 Amp	Watt, VAR	– 5	1000 watts (VARs) per element
15 Amp	Watt, VAR	– 7	1500 watts (VARs) per element
25 Amp	Watt, VAR	– 8	2500 watts (VARs) per element
10 Amp	Current	– 1	0-10 A input
25 Amp	Current	– 2	0-25 A input
240 Volt	Voltage	– 1	0-300 V input
480 Volt	Voltage	– 2	0-600 V input
25 Hz	Watt, Current, Voltage	– 25	
50 Hz	All models	– 12	
400 Hz	Most models	– 6	

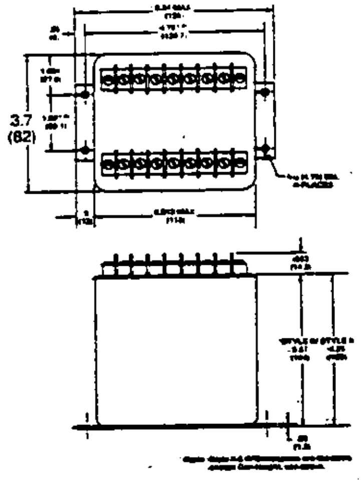
SURGE WITHSTAND CAPABILITY (SWC)
ANSI C37.90a/IEEE 472
Applies to all Scientific Columbus Transducers

Scientific Columbus Transducers are capable of meeting the IEEE Standard Surge Withstand Capability Test: The SWC test wave is an ocillatory wave, frequency range 1.0 MHz to 1.5 MHz, voltage range of 2.5KV to 3.0 KV crest value of the first half cycle peak, envelope decaying to 50% of the crest value of the first peak in not less than 6 microseconds from the start of the wave. The source impedance of the surge generator used to produce the test wave shall be 150—2. The test wave to [illegible] applied to a test specimen at a repetitive rate of not less than 50 tests per second for a period of not less than 2.0 seconds.

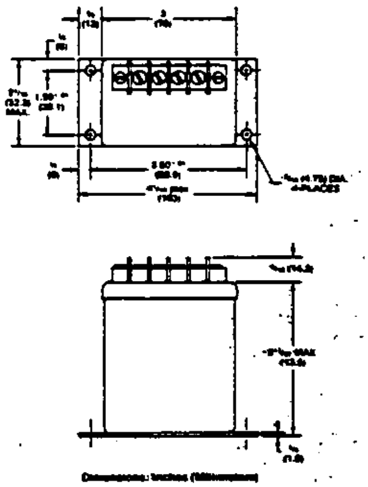
Outline Dimensions
Style I, II, III, IV, XP Series and JEM



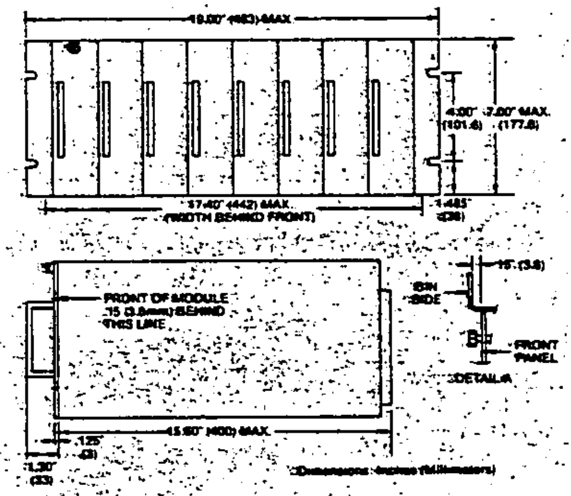
Style I



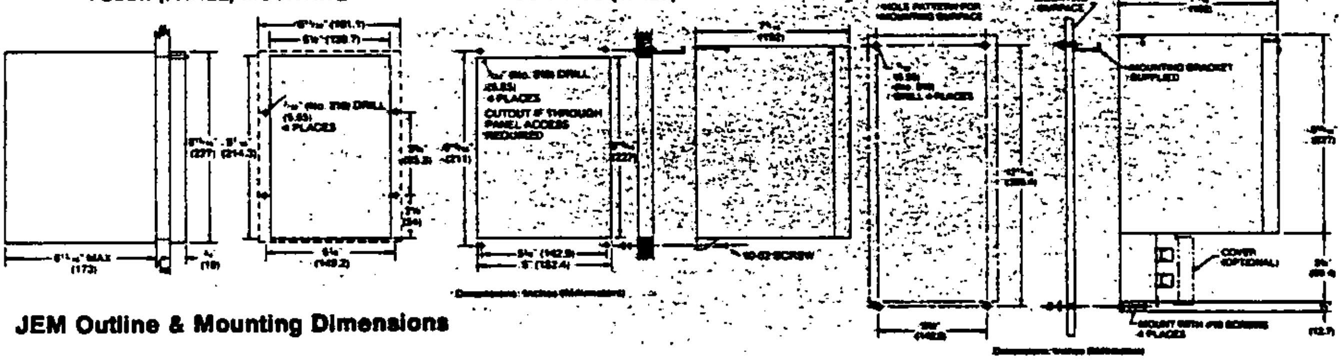
Styles II and IV



Style III



XP Series Dimensions

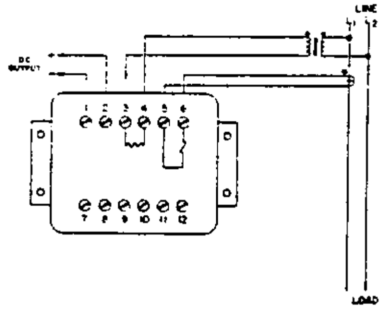


JEM Outline & Mounting Dimensions

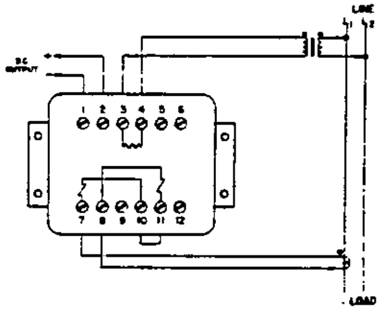
Product Connection Diagrams

** See important notice below*

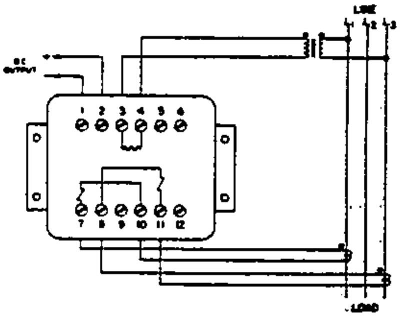
48-A



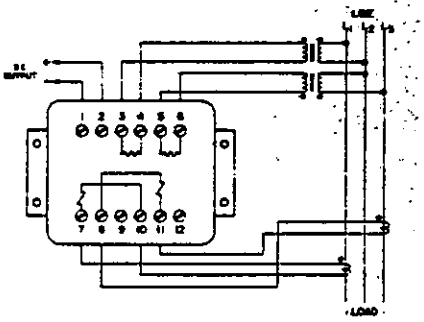
48-B



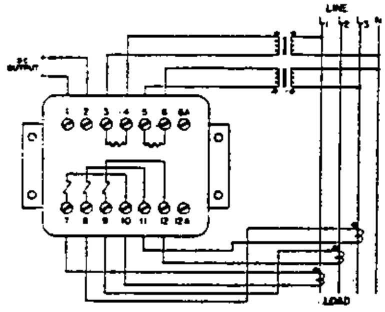
48-C



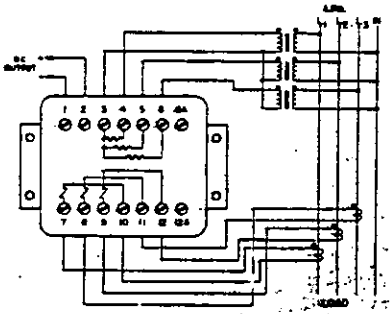
48-D



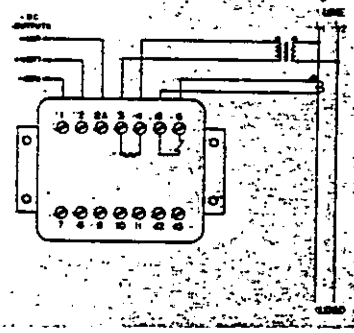
48-E



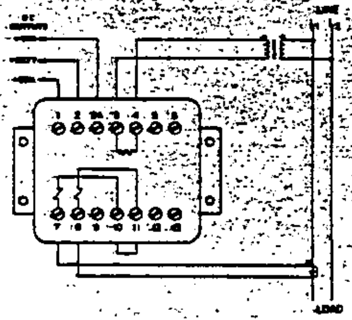
48-F



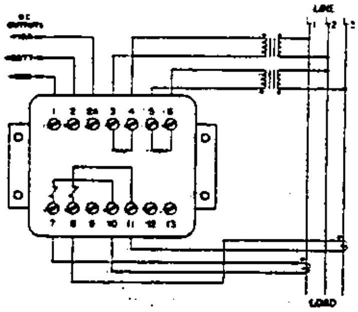
48-G



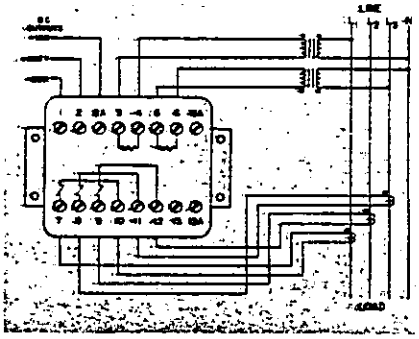
48-H



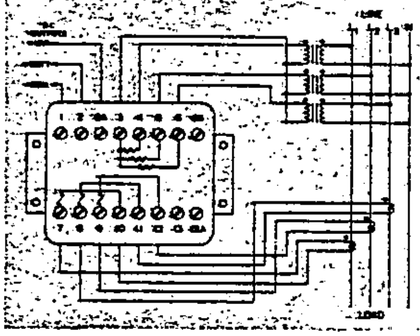
48-I



48-J



48-K

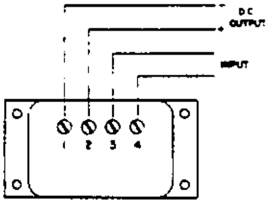


***NOTICE:** 120 V AC External Amplifier Power, when required, is supplied to terminals as follows:

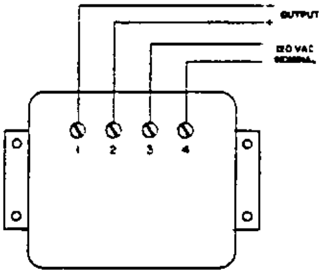
	Terminals 9 & 12	Terminals 6A & 12A
Conn:	48-A	48-D (2½ ele)
	48-B	48-E
	48-C	48-F
	48-D (2 ele)	48-J
	48-G	48-K
	48-H	
	48-I	

Product Connection Diagrams

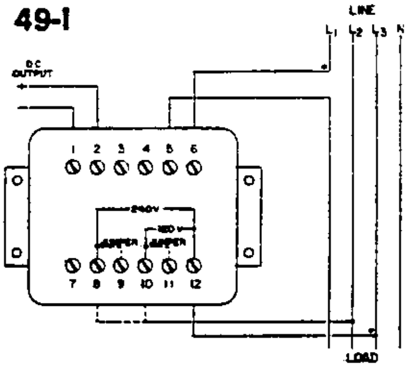
49-A



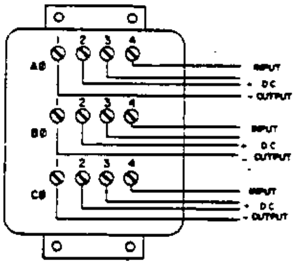
49-E



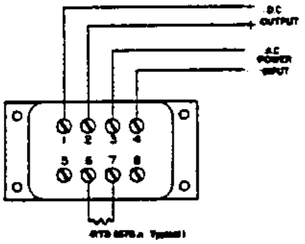
49-I



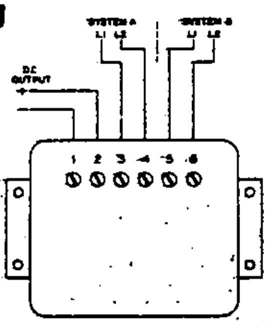
49-B



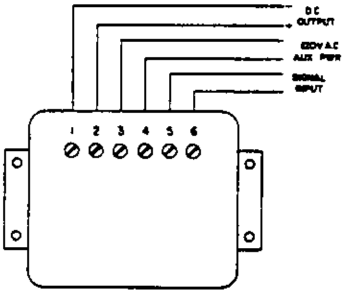
49-F



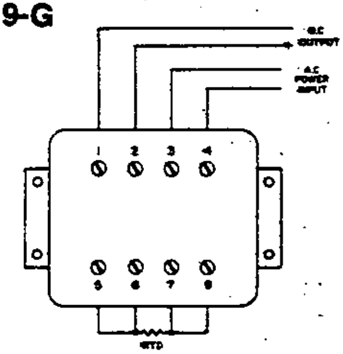
49-J



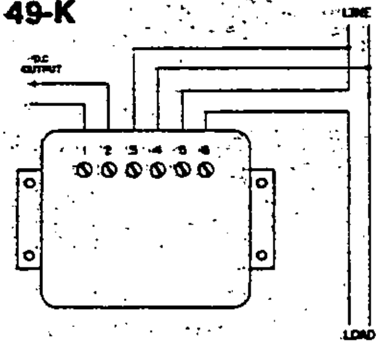
49-C



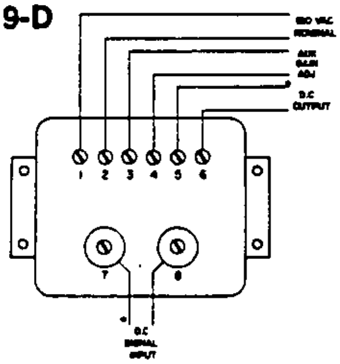
49-G



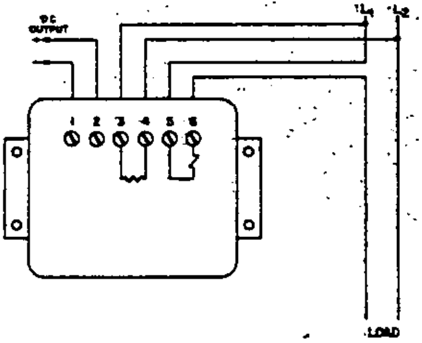
49-K



49-D



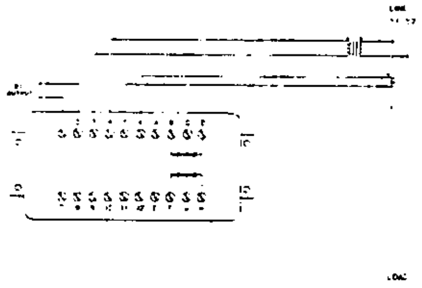
49-H



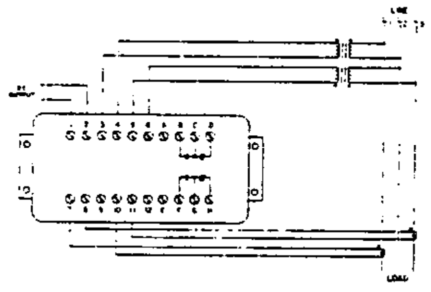
Product Connection Diagrams

* See important note below

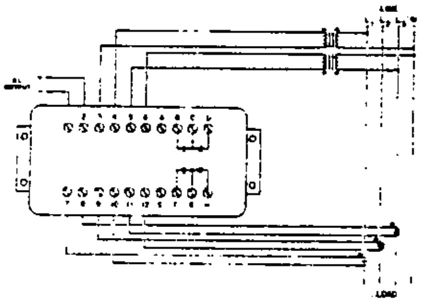
50-A



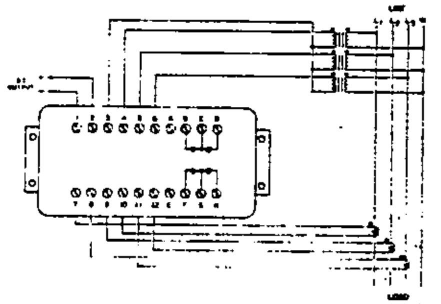
50-B



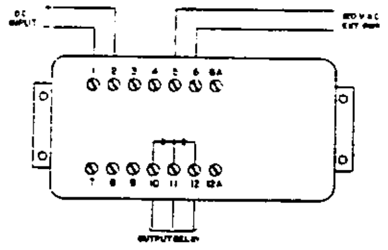
50-C



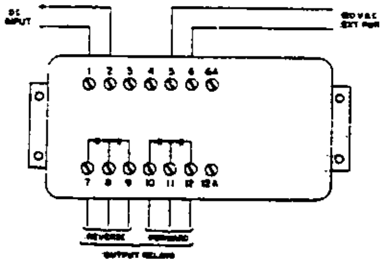
50-D



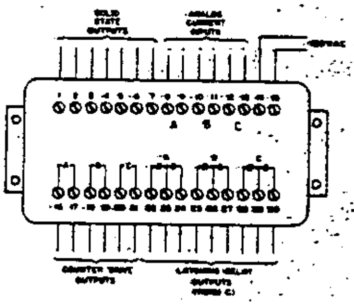
50-E



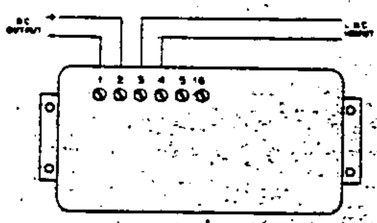
50-F



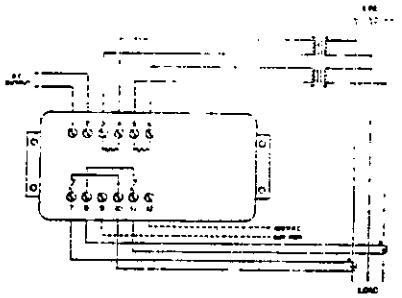
50-G



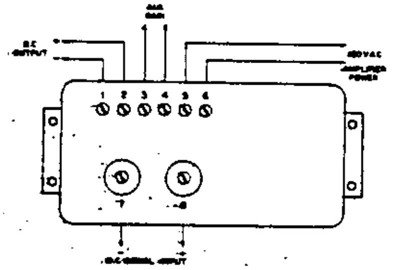
50-H



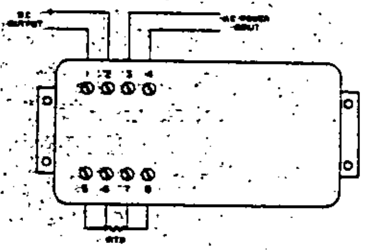
50-I



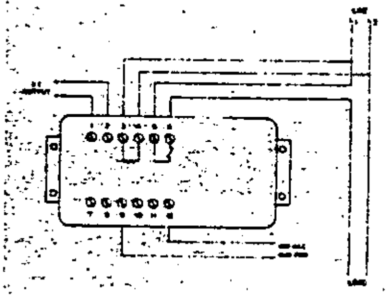
50-J



50-K



50-L



*** NOTICE: 120 V AC External Amplifier Power, when required, is supplied to Terminals as follows:**

Terminals 9 & 12	Terminals A & E	Terminals 5 & 6	Terminals 14 & 15	Terminals 3 & 4
Conn: 50-A	50-C	50-E	50-G	50-K
50-B	50-D	50-F		
50-L		50-H		
		50-J		

* Please see page 48 for Watt and Var connections — same for "P" series.

Printed in U.S.A.
Form #487-10M

SCIENTIFIC COLUMBUS
AN ESTERLINE COMPANY

SCIENTIFIC COLUMBUS, INC. 1900 ARLINGATE LANE, COLUMBUS, OHIO 43228 • TELEPHONE (614) 274-7160

YD-08736-001-N

INSTRUCTION MANUAL
FOR
EXCELTRONIC WATT AND VAR
TRANSDUCERS

Revised
3/15/83

WARRANTY AND REPAIRS

The products sold hereunder are warranted as free from defects of materials and workmanship and in conformance with specifications. There are no other oral, statutory, or implied warranties. Seller's obligation hereunder shall be and is limited to replacing f.o.b. its plant in Columbus, Ohio, or such other point as Seller may designate, or refund the purchase price of, any such product which proves to be defective in material or workmanship or which fails to conform to specifications therefore, provided that (1) written notice of such defect or failure is received by Seller from Purchaser within one year after the date of shipment of such products by Seller, and (2) such defects, in the opinion of Seller, shall not have arisen from improper use. The absence of such written notice of defect or failure or lack of conformance to specifications within the specified time shall constitute a waiver of any claim. Seller may, after receipt of notice, require purchaser to send said products, transportation prepaid, to Seller for its examination and inspection.

TABLE OF CONTENTS

EXCELTRONIC

WATT AND VAR TRANSDUCERS

DESCRIPTION

The Scientific Columbus EXCELTRONIC Watt and Var Transducers are state-of-the-art, high-reliability electronic devices that provide a dc current output signal which is very accurately proportional to input watts or vars. The excellent accuracy, long-term stability, and very low error influences are made possible at economical prices by use of patented and patent-pending techniques. Many features of the outstanding DIGILOGIC Transducer series have been utilized along with new developments to make an unprecedented performance/value combination.

The EXCELTRONIC series is available in 1, 1-1/2, 2, 2-1/2, and 3-element configurations. All models are packaged in the same small case which measures only 5-5/16" by 3-11/16" by 4-13/16". They are physically interchangable with the Halltiplier series transducers and have the same identical electrical connections, making it easy to upgrade existing installations where improved performance is desired. Nominal input ratings are 120 V and 5 A per element. Standard calibration is 1 mA output for 500 watts (or vars) per element.

SPECIFICATIONS

FOR

EXCELTRONIC WATT TRANSDUCER XL-A2/A4 SERIES

General Specifications

Function	High accuracy watt transducer
Phases	1 or 3
Elements	1, 1-1/2, 2, 2-1/2, 3
Calibrating Input	500 watts/element
Rated Output (RO)	1 mA dc into 0-10 kilohms at calibrating watts (polarity reverses for reverse power flow)
Potential Input	120 volts nominal
Operating Range	0-150 volts (85-135 volts for A4 Series)
Overload, continuous	175 volts
Burden, at 120 V	0.05 VA maximum per element (1.75 VA for A4 Series)
Current Input	5 amperes nominal
Linear Operating Range	0-10 amperes
Overload, continuous	15 amperes
Overload, 10 sec./hr.	50 amperes
Overload, 1 sec./hr.	400 amperes
Burden, at 5 A	0.1 VA maximum per element (0.2 VA on 1 element units)
Frequency Range	± 10 Hz of calibration (60 Hz standard)
Power Factor Range	No restriction
Temperature	
Normal Operating Range	25°C ± 5°C
Extended Operating Range	-20°C to +70°C
Additional Influence on Accuracy (extended range)	± 0.005% of reading/°C
Storage Range	-40°C to +82°C
Humidity	0% to 95%

Accuracy	± (0.2% Reading + 0.01% RO), including all stated variables except extended temperature range, 0% to 200% of calibrating watts.
Output	± 1 mA at calibrating watts
Stability	± 0.1% RO/year
Load	0-10 kilohms
Compliance	11 volts minimum
Low Impedance Terminal	# 2
Impedance	100 megohms minimum
Response Time, to within 99% of final value after step change	400 ms, maximum
Ripple, peak	0.5% RO, maximum
Calibration Adjustment Range	± 2% RO minimum
Zero Adjustment	None required
Auxiliary Power	85-135 Vac, 60 Hz ± 10 Hz
Burden at 120 V	1.5 VA maximum
Protection	
Isolation	Complete: Input/Output/Power/Case
Dielectric	1800 V rms for 1 minute or 2200 V for 1 second
Surge	Withstands IEEE SWC test
Packaging and Connections	See drawings on following pages
Weight: 1 element	2 pounds, 2 ounces (0.96 kg)
2 element	2 pounds, 10 ounces (1.19 kg)
3 element	3 pounds, 2 ounces (1.42 kg)
Options*	Calibration Frequency (40-400) Nominal Voltage Variations (60-480) Nominal Ampere Variations (1-20) Voltage Outputs (0-10 V) (Output impedance = 1000 ohms/V)

* Variations from standard calibration will possibly require some specifications to be relaxed or changed to be applicable to the option requested.

SPECIFICATIONS
FOR
EXCELTRONIC VAR TRANSDUCER XLV-A2/A4 SERIES

General Specifications

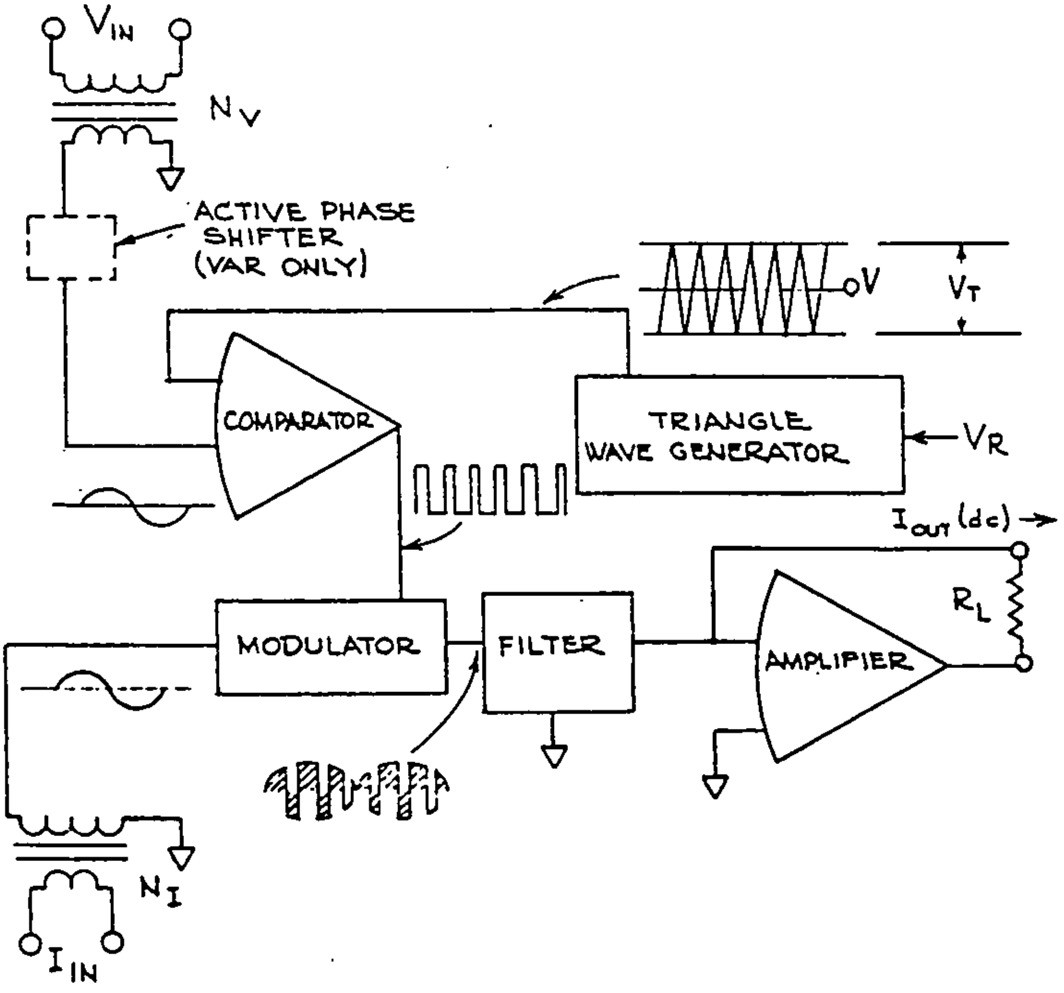
Function	High accuracy var transducer
Phases	1 or 3
Elements	1, 1-1/2, 2, 2-1/2, 3
Calibrating Input	500 vars/element
Rated Output (RO)	1 mA dc into 0-10 kilohms calibrating vars lag input (polarity reverses for lead)
Potential Input	120 volts nominal
Operating Range	0-150 volts (85-135 volts for A4 Series)
Overload, continuous	175 Vac
Burden at 120 V	0.05 VA maximum per element (1.75 VA for A4 Series)
Current Input	5 amperes
Linear Operating Range	0-10 amperes
Overload, continuous	15 amperes
Overload, 10 sec./hr.	50 amperes
Overload, 1 sec./hr.	400 amperes
Burden at 5 A	0.1 VA maximum per element (0.2 VA for 1 element units)
Frequency Input	60 Hz (standard)
Power Factor Range	No restriction
Temperature	
Normal Operating Range	25°C ± 5°C
Extended Operating Range	-20°C to +60°C
Additional Influence on Accuracy (extended range)	± 0.005% of Reading/°C, typical
Storage Range	-40°C to +82°C
Humidity	0% to 95%

Accuracy	± (0.2% Reading + 0.02% RO), including all stated variables except extended temperature range, 0% to 200% of calibrating vars.
Output	± 1 mA dc at calibrating vars
Stability	± 0.2% RO/year typical
Load	0-10 kilohms
Compliance	11 volts minimum
Low Impedance Terminal	# 2
Impedance	100 megohms minimum
Response Time, to within 1% of RO of nominal output after step change	400 ms, maximum
Ripple, peak	0.5% RO, maximum
Calibration Adjustment	± 2% RO minimum
Zero Adjustment	None required
Auxiliary Power	85-135 Vac, 60 Hz ± 10 Hz
Burden at 120 V	1.5 VA maximum
Protection	
Isolation	Complete: Input/Output/Power/Case
Dielectric	1800 V rms for 1 minute or 2200 for 1 second
Surge	Withstands IEEE SWC test
Packaging and Connections	See drawings on following pages
Weight: 1 element	2 pounds, 2 ounces (0.96 kg)
2 element	2 pounds, 10 ounces (1.19 kg)
3 element	3 pounds, 2 ounces (1.42 kg)
Options*	Calibration Frequency (40-400) Nominal Voltage Variations (60-480) Nominal Current Variations (1-20) Voltage Outputs (0-10 V) (Output impedance = 1000 ohms/V)

* Variations from standard calibration will possibly require some specifications to be relaxed or changed to be applicable to the option requested.

THEORY OF OPERATION

The Exceltronic transducers use the time-division multiplier principle which depends on combined pulse-width and pulse-amplitude modulation of a rectangular pulse train. Referring to the block diagram, it is seen that the input voltage, V_{in}, is ratioed downward by the potential transformer and converted into a variable pulse-width wave train by the comparator and triangle wave generator. In var transducers an active phase shifter introduces exactly 90 degrees phase shift just ahead of the comparator. The input current, I_{in}, is ratioed downward by the current transformer and is pulse-width modulated in the modulator by the comparator output signal. This pulse-width, pulse-height signal, whose average value is a dc current proportional to watts or vars, is filtered and fed to the external load by the unity gain output amplifier.



Simplified Block Diagram, Single Element Transducer

The input current signal is never converted to a voltage internally, hence offset voltages and other voltage errors and drifts have little influence on the accuracy and stability of the transducer and the need for a "zero" adjustment is eliminated. The output impedance is extremely high, making the output current practically unaffected by load resistance changes within the voltage compliance limitations of the amplifier.

Only the transformer ratios and the highly stable triangle wave voltage enter directly into the transfer function, resulting in excellent long-term stability and low temperature influence. The transformer ratios, of course, do not change and the triangle wave is controlled by a very stable reference zener diode.

The transfer equation for watt transducers is:

$$I_{out} = \frac{K\ I_{in}\ V_{in}}{V_T\ N_V\ N_I} \cos \theta$$

and for var transducers:

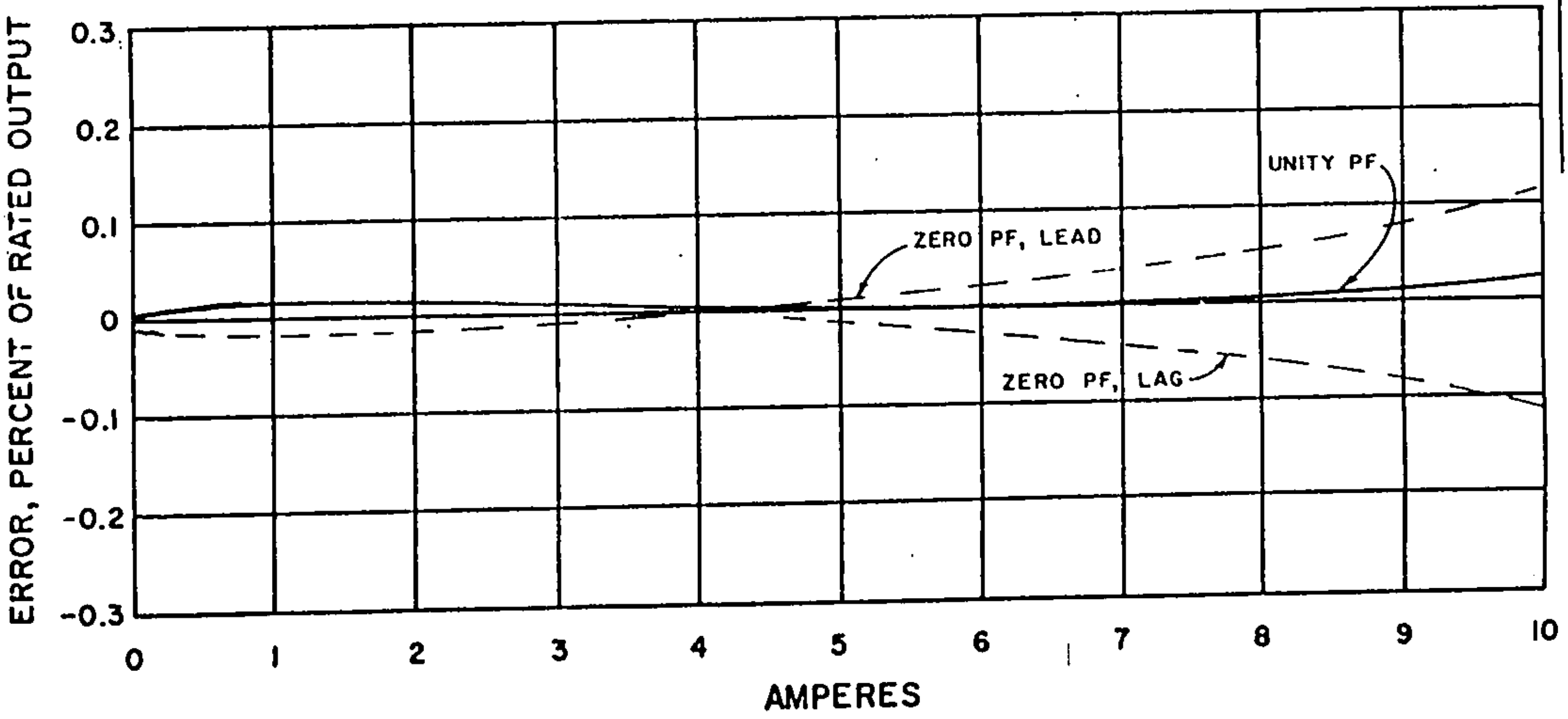
$$I_{out} = \frac{K\ I_{in}\ V_{in}}{V_T\ N_V N_I} \sin \theta$$

K is a proportionality constant and θ is the phase angle between V_{in} and I_{in}. V_T is the triangle wave amplitude. N_V and N_I are the potential and current transformer ratios.

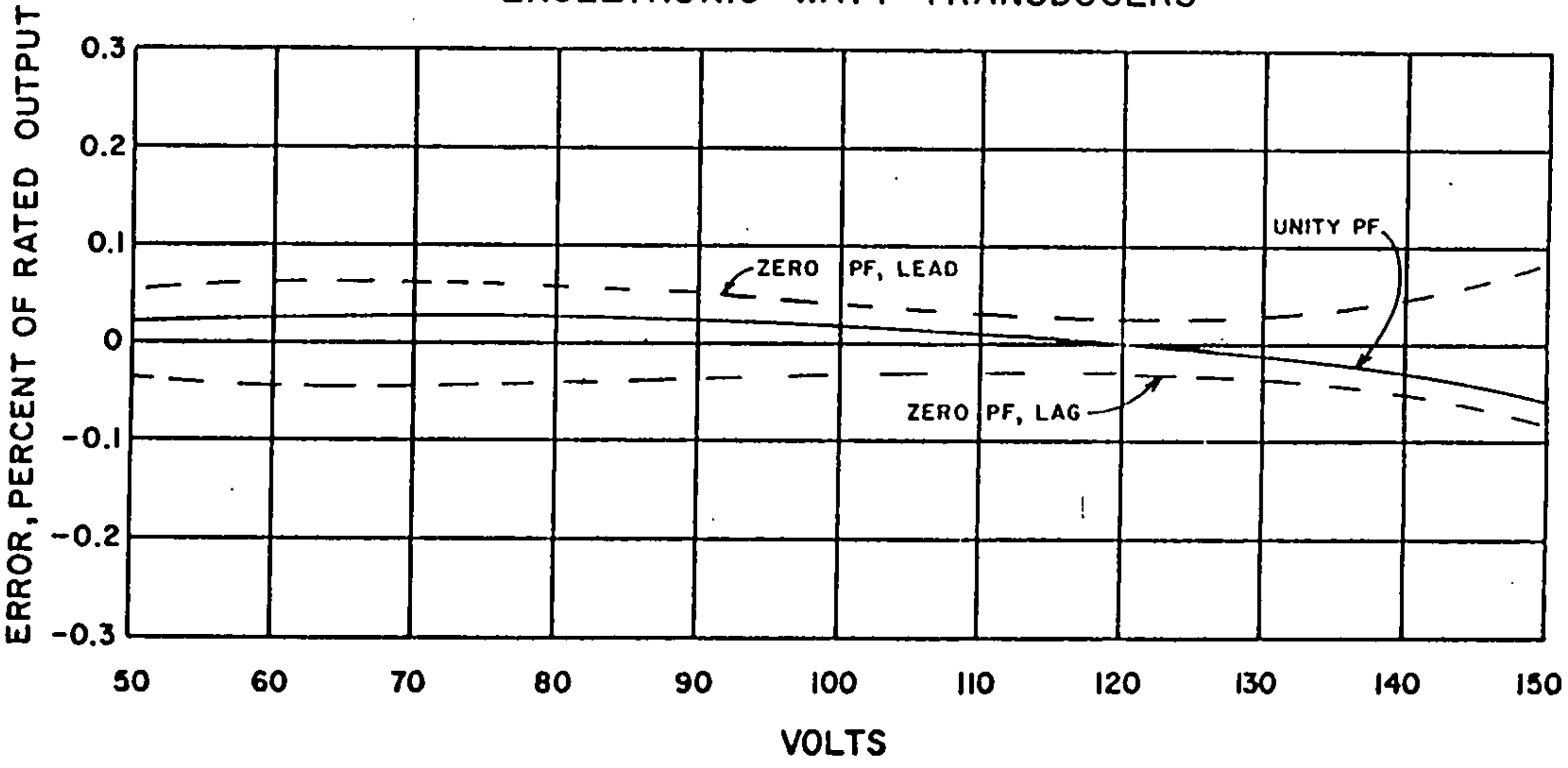
The input transformers are designed to give excellent linearities over wide operating ranges and are rated for 1,800 volts rms dielectric test. Burdens are very low; less than 0.1 VA and 0.2 VA for potential and current, respectively, at nominal input levels.

The power supply is well regulated and its burden is less than 1.5 VA at 120 volts. Line voltage variations from 85 to 150 volts have practically no influence on the transducer performance.

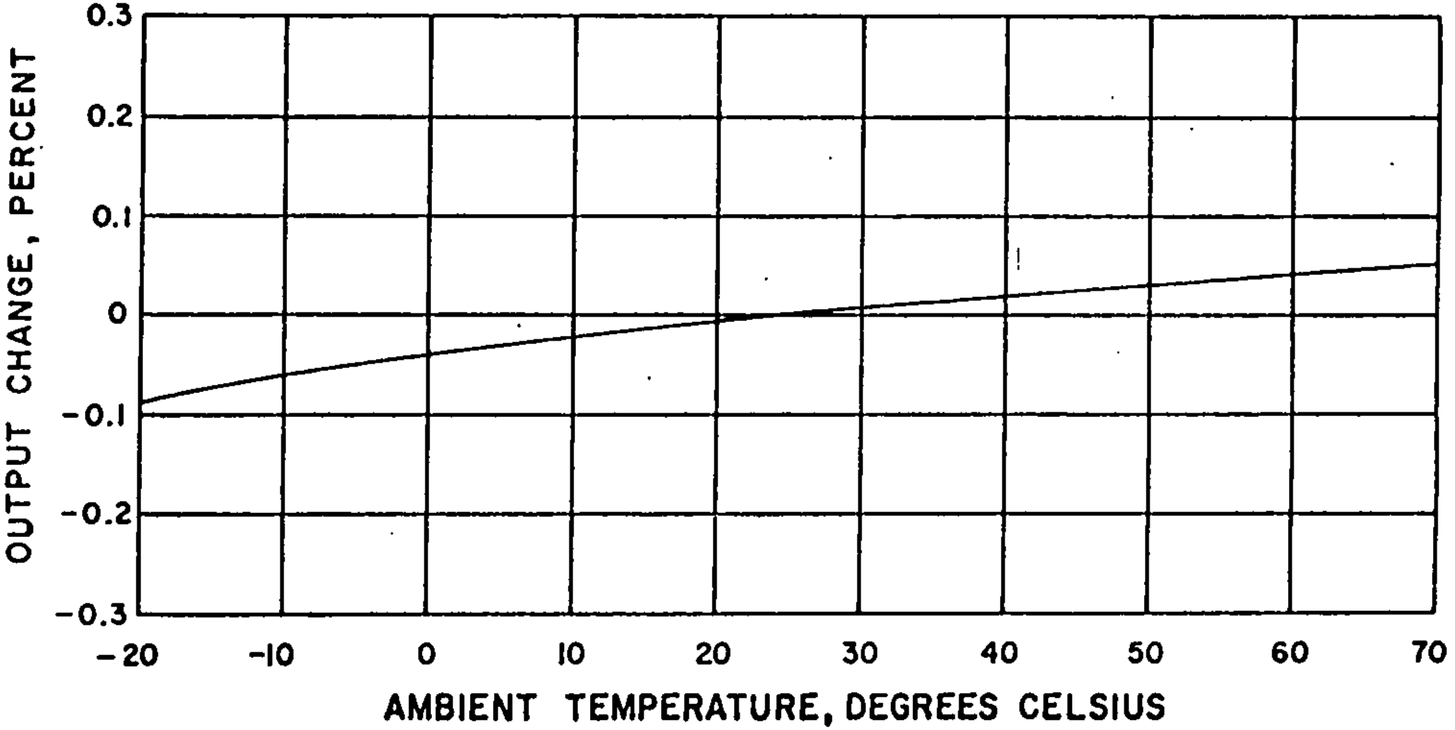
TYPICAL CURRENT LINEARITY
EXCELTRONIC WATT TRANSDUCERS



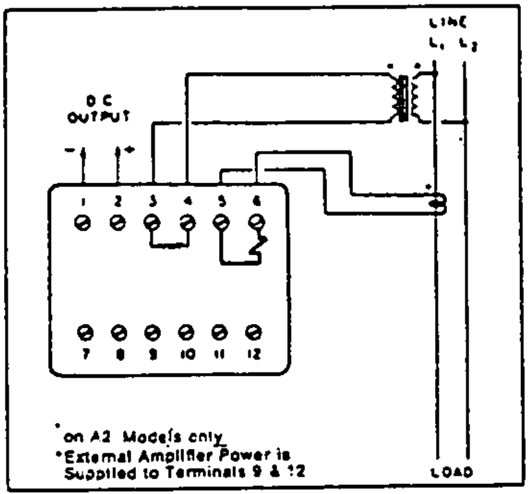
TYPICAL VOLTAGE LINEARITY
EXCELTRONIC WATT TRANSDUCERS



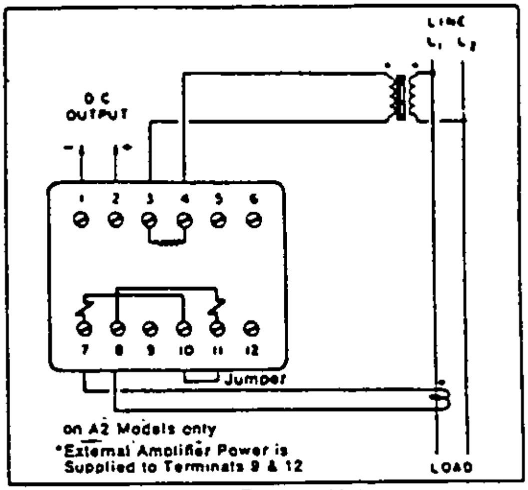
TYPICAL TEMPERATURE INFLUENCE
EXCELTRONIC WATT TRANSDUCERS



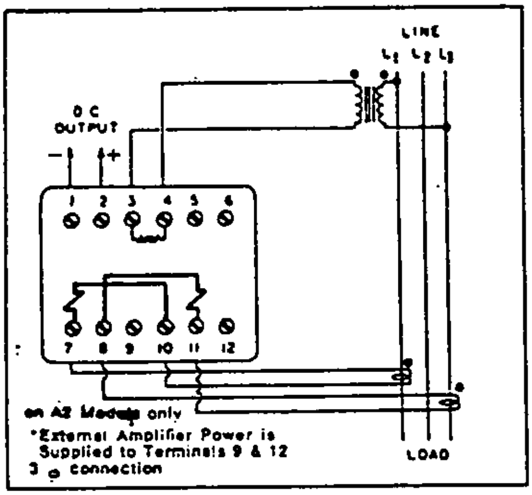
CONNECTION DIAGRAMS



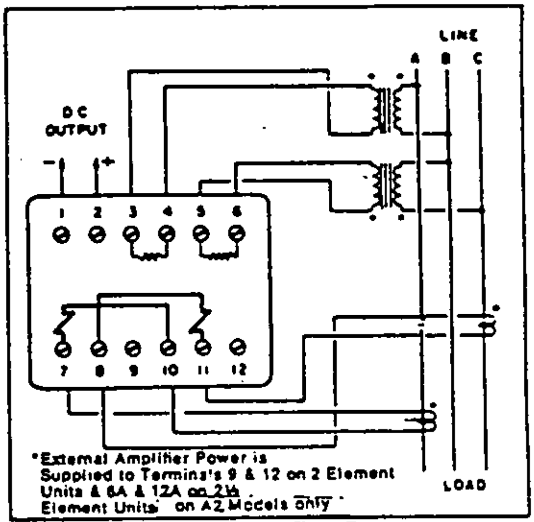
Watt or Var Single Phase One Element Units



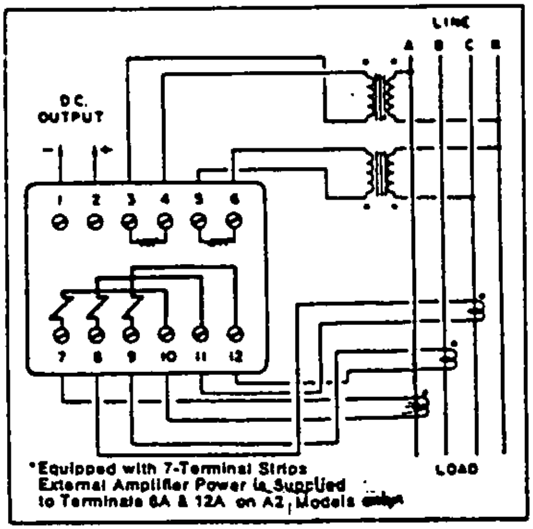
Watt Single Phase 1½ Element Units



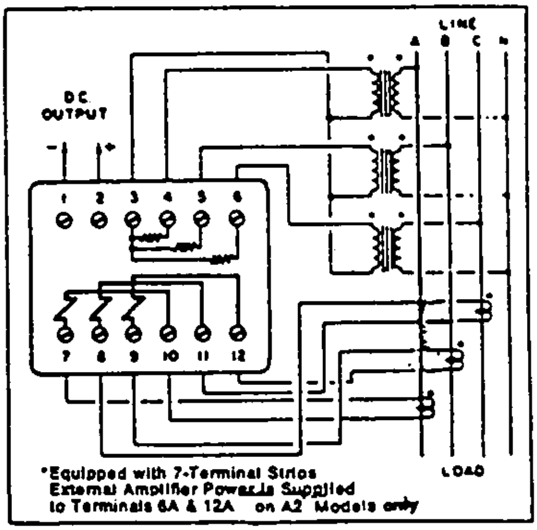
Watt Three Phase 1½ Element Units



Watt or Var 3 Phase, 3 Wire Two Element or 2½ Element Units



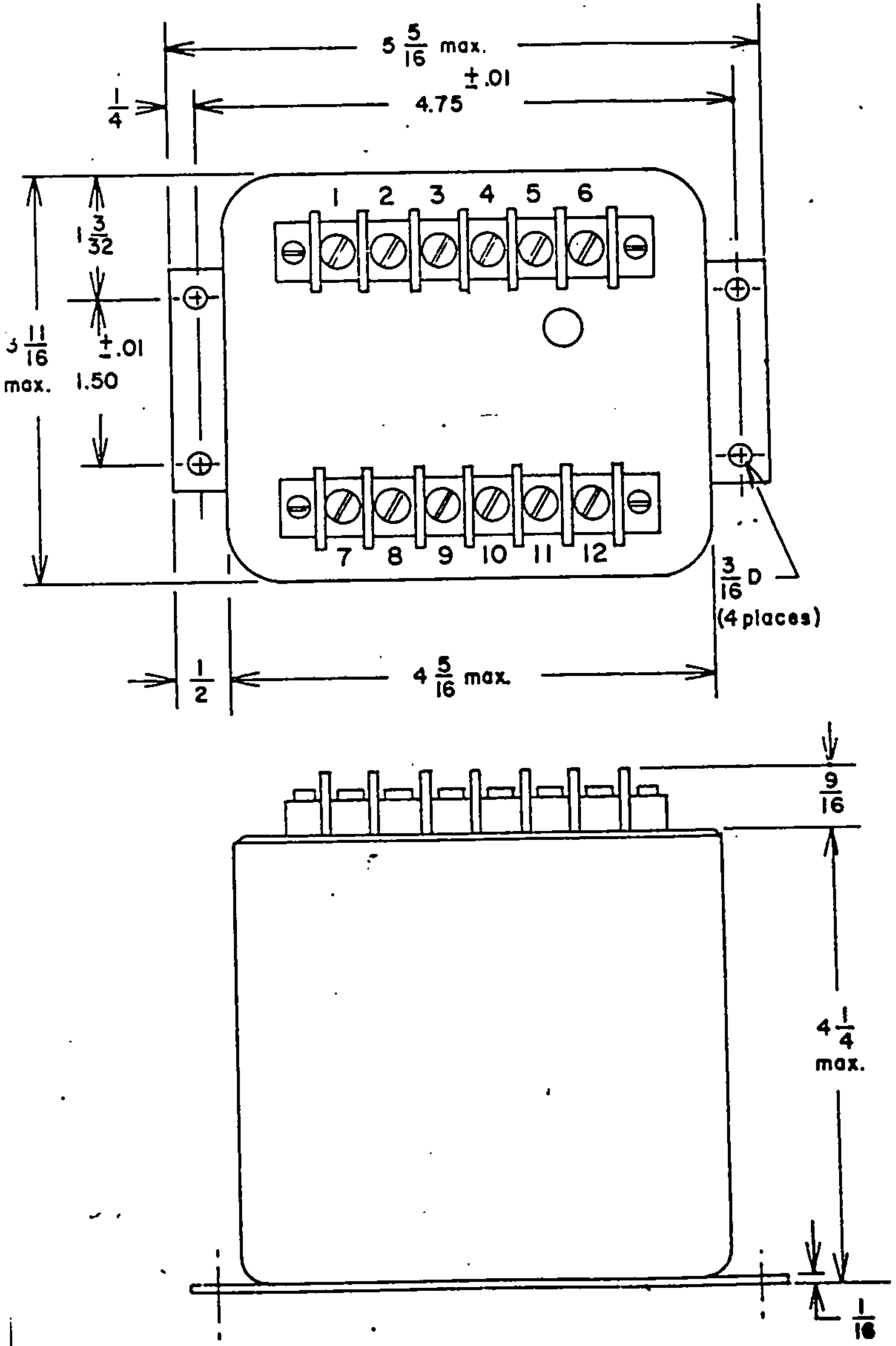
Watt or Var 3 Phase, 4 Wire 2½ Element Units

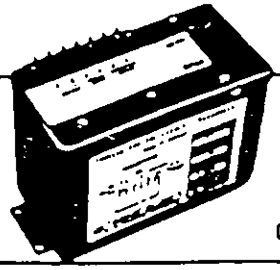


Watt or Var 3 Phase, 4 Wire Three Element Units

* External amplifier voltage is not required on the A4 Series transducers.

OUTLINE DIMENSIONS





EXCELTRONIC™ POWER TRANSDUCER

P SERIES

AN6 1-5 MA
AN7 4-20 MA
AN8 10-50 MA

DESCRIPTION

SCIENTIFIC COLUMBUS HAS OVER 60 HIGH OUTPUT CONSTANT CURRENT TRANSDUCERS AVAILABLE FOR YOUR SELECTION. THESE TRANSDUCERS MEASURE VOLTAGE,CURRENT,WATTS,VARS, FREQUENCY AND POWER FACTOR,WITH THE POPULAR OUTPUTS COMPATABLE WITH CONTROL EQUIPMENT.

ALL THE TRANSDUCERS CAN BE FIELD CONVERTED TO HAVE 1-5, 4-20,OR 10- 50 MA OUTPUTS PROPORTIONALTO INPUT. WHEN ORDERING ,ADD THE SUFFIX AN6,AN7,AN8 TO THE MODEL NUMBERS DESCRIBED IN THIS BULLETIN. THE UNITS WILL BE DELIVERED PRECALIBRATED FOR THE DESIRED OUTPUT. AN6 IS THE 1-5 MA CALIBRATION; AN7 IS THE 4-20 CALIBRATION AND AN8 IS THE 10-50 CALIBRATION

CALIBRATION FOR THE WATT AND VAR MODELS MUST BE DESIGNATED AS - U FOR UNIDIRECTIONAL WHERE ZERO INPUT RESULTS IN THE MINIMUM OUTPUT (1 MA OR 4 MA OR 10 MA RESPECTIVELY) OR -B FOR BI-DIRECTIONAL WHERE ZERO INPUT IS MID- RANGE OUTPUT (3 MA OR 12 MA OR 10 MA RESPECTIVELY). THE MID- RANGE OUTPUT IS EASILY OBTAINED BY A JUMPER CHANGE AND A SLIGHT RECALIBRATION

SPECIFICATIONS COMMON TO WATT AND VAR MODELS

NOMINAL VOLTAGE INPUT	120 V
VOLTAGE RANGE	0-135V
PERMISSIBLE VOLTAGE OVERLOAD	150 V
VOLTAGE BURDEN (PER ELEMENT)	0.05 VA AT 120V
NOMINAL CURRENT INPUT	5A
PERMISSABLE CURRENT OVERLOAD	10 A CONTINUOUS
	250 A FOR 1 SEC
CURRENT BURDEN (PER ELEMENT)	0.10 VA AT 5A
EXTERNAL POWER REQUIRED	100- 130V
	50 HZ-500 HZ 8 VA
DIELECTRIC TEST	1500 V RMS
CONNECTIONS	SEE REVERSE SIDE OF THIS SHEET

FREQUENCY RANGE (WATTS)	50-60 HZ
FREQUENCY RANGE (VARS)	60 HZ
POWER FACTOR RANGE	ANY
TEMPERATURE RANGE	0-50 °C
TEMPERATURE EFFECT ON ACCURACY	± 0.0075 % / °C
ACCURACY/LINEARITY @ 25°C	± 0.25 %
AC COMPONENT (P TO P)	0.5 % MAX
RESPONSE TIME	1 SECOND MAX
ZERO ADJUST	± 5 % OF ZERO POINT
CALIBRATION ADJUSTMENT	± 20 %
AN6 OUT PUT	1-5 MA INTO 0 TO 3000 Ω
AN7 OUT PUT	4-20 MA INTO 0 TO 750 Ω
AN8 OUT PUT	10-50 MA INTO 0 TO 300 Ω

ADDITIONAL SPECIFICATIONS FOR WATT MODELS

MODEL NO.*	CIRCUIT	FULL SCALE CALIBRATION WATTS
XL5C5P	1 Ø 2 WIRE	500 WATTS
XL31K5P	3 Ø 3 WIRE	1000 WATTS
XL31K52 1/2 P	3 Ø 4 WIRE	1500 WATTS
XL342K5P	3 Ø 4 WIRE	1500 WATTS

ADDITIONAL SPECIFICATIONS FOR VAR MODELS

MODEL NO.*	CIRCUIT	FULL SCALE CALIBRATION VARS
XLV5C5P	1 Ø 2 WIRE	500 VARS
XLV31K5P	3 Ø 4 WIRE	1000 VARS
XLV31K52 1/2 P	3 Ø 3 WIRE	1500 VARS
XLV 342K5P	3 Ø 4 WIRE	1500 VARS

* ADD SUFFIX AN6, AN7, AN8, TO MODEL NUMBER

SPECIFICATIONS COMMON TO VOLT, CURRENT, POWER FACTOR, FREQUENCY, AND ISOLATION TRANSDUCERS

NOMINAL VOLTAGE INPUT	120 V	
PERMISSABLE VOLTAGE OVERLOAD	150 V	
VOLTAGE BURDENS	3 VA MAX	
CURRENT CIRCUITS NOMINAL INPUTS	5A	
PERMISSABLE CURRENT OVERLOAD	10 A CONT	
	250 FOR 1 SEC	
CURRENT CIRCUIT BURDENS	3 VA	
EXTERNAL POWER REQUIRED	100 - 130 V	
	50 TO 500 HZ	8 VA
DIELECTRIC TESTS	1500 V RMS	
(ISOLATION UNIT) INPUT TERMINALS	4000 V D C	

TEMPERATURE RANGE	0 - 50 °C
TEMPERATURE AFFECT ON ACCURACY	± 1 %
ACCURACY / LINEARITY @ 25 °C	± 0.5 %
AC COMPONENT (P-P)	± 0.5 % MAX.
RESPONSE TIME	1 SEC MAX
ZERO ADJUST	± 5 % OF ZERO POINT
CALIBRATION ADJUST	± 20 %
AN6 OUTPUT	1-5 MA INTO 0 - 3000 Ω
AN7 OUT PUT	4-20 MA INTO 0 - 750 Ω
AN8 OUT PUT	10 - 50 MA INTO 0 - 300 Ω

SPECIFICATIONS:VOLTS, CURRENT,FREQUENCY,POWER FACTOR ,ISOLATION AMPLIFIER

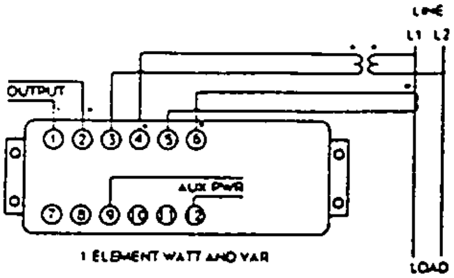
MODEL NO*	TYPE	FULL SCALE CAL.
6271 P	ISOLATION	0 - 100 MV
PF1 P	POWER FACTOR	0.3 - 1 - 0.3 PF
PF2 P	POWER FACTOR	0.5 - 1 – 0.5PF
PF3 P	POWER FACTOR	0.7 - 1 - 0.7PF
PF34 P	POWER FACTOR	0.5 - 1 - 0.5PF

MODEL NO	TYPE	FULL SCALE CAL
VT110 P	VOLTAGE	0 - 150 V
CT510 P	CURRENT	0 - 5 A
6281 P	FREQUENCY	45 - 55 HZ
6284 P	FREQUENCY	55 - 65 HZ
6283 P	FREQUENCY	375 - 425 HZ

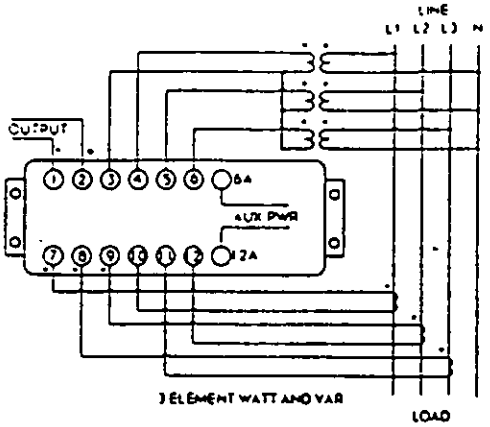
* ADD SUFFIX AN6, AN7, AN8, TO MODEL NUMBER

SCIENTIFIC COLUMBUS *THE METERING AND INSTRUMENTATION PEOPLE*

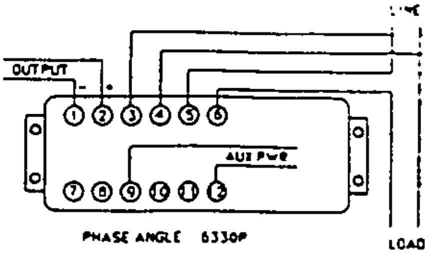
Product Connection Diagrams



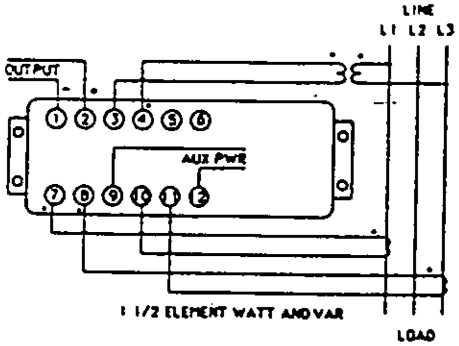
1 ELEMENT WATT AND VAR



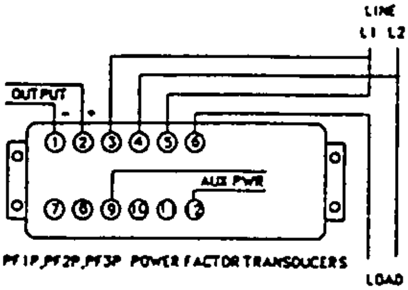
3 ELEMENT WATT AND VAR



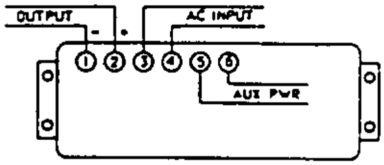
PHASE ANGLE 6330P



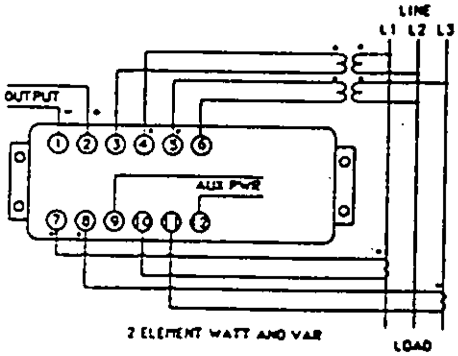
1 1/2 ELEMENT WATT AND VAR



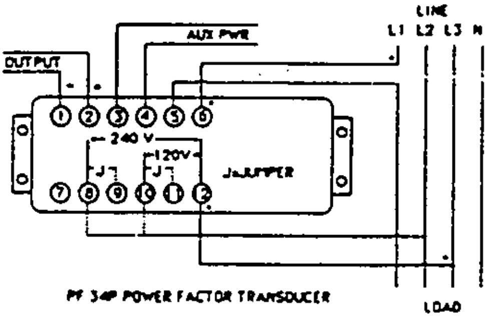
PF1P, PF2P, PF3P POWER FACTOR TRANSDUCERS



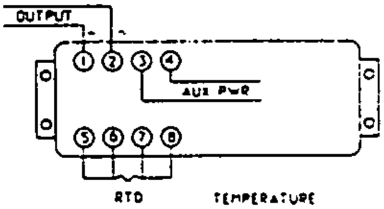
VOLT, CURRENT, AND FREQUENCY



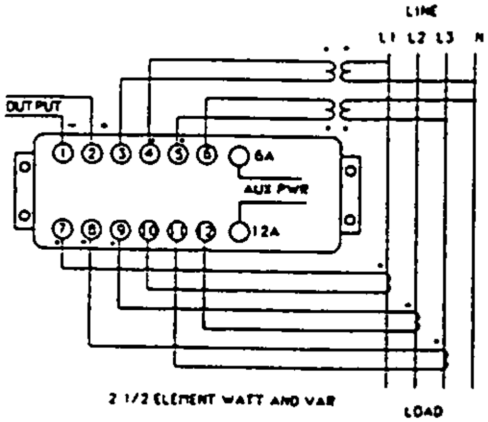
2 ELEMENT WATT AND VAR



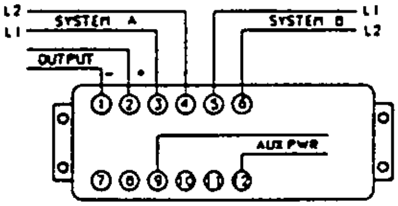
PF 34P POWER FACTOR TRANSDUCER



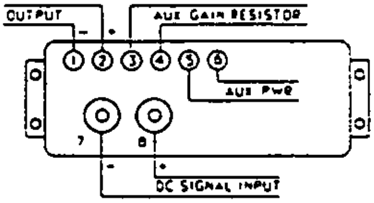
TEMPERATURE



2 1/2 ELEMENT WATT AND VAR



PHASE ANGLE 6314P



ISOLATION AMPLIFIER

SCIENTIFIC COLUMBUS
AN ESTERLINE COMPANY

THE METERING AND INSTRUMENTATION PEOPLE

SCIENTIFIC COLUMBUS INC., 1000 ARLINGATE LANE, COLUMBUS, OHIO

ANALOG TO BINARY CODED RELAY OUTPUT

CAD1941

Description:

The Model CAD1941 Converter was designed to provide a binary coded relay contact closure for a zero to 1 mA dc input signal. The relay outputs represent the 7 bit binary logic of the input signal.

The output relays are commoned at terminal 16 and individually brought out at terminals 9 through 15, with terminal 9 "LSB" and terminal 15, the "MSB".

Each relay contact is protected with an RC network of .22 ufd and a 249 ohm resistor.

The external sample input voltage is required to be activated before reading the coded outputs. When the input pulse of 24V dc is applied to this input, an internal signal is fed to the ADC converter which updates all output relays. The output relays will remain in the new state until another input sample pulse is initiated.

The maximum sample rate is 50 milliseconds. The external sample pulse width should be less than 25 milliseconds to accomplish this rate.

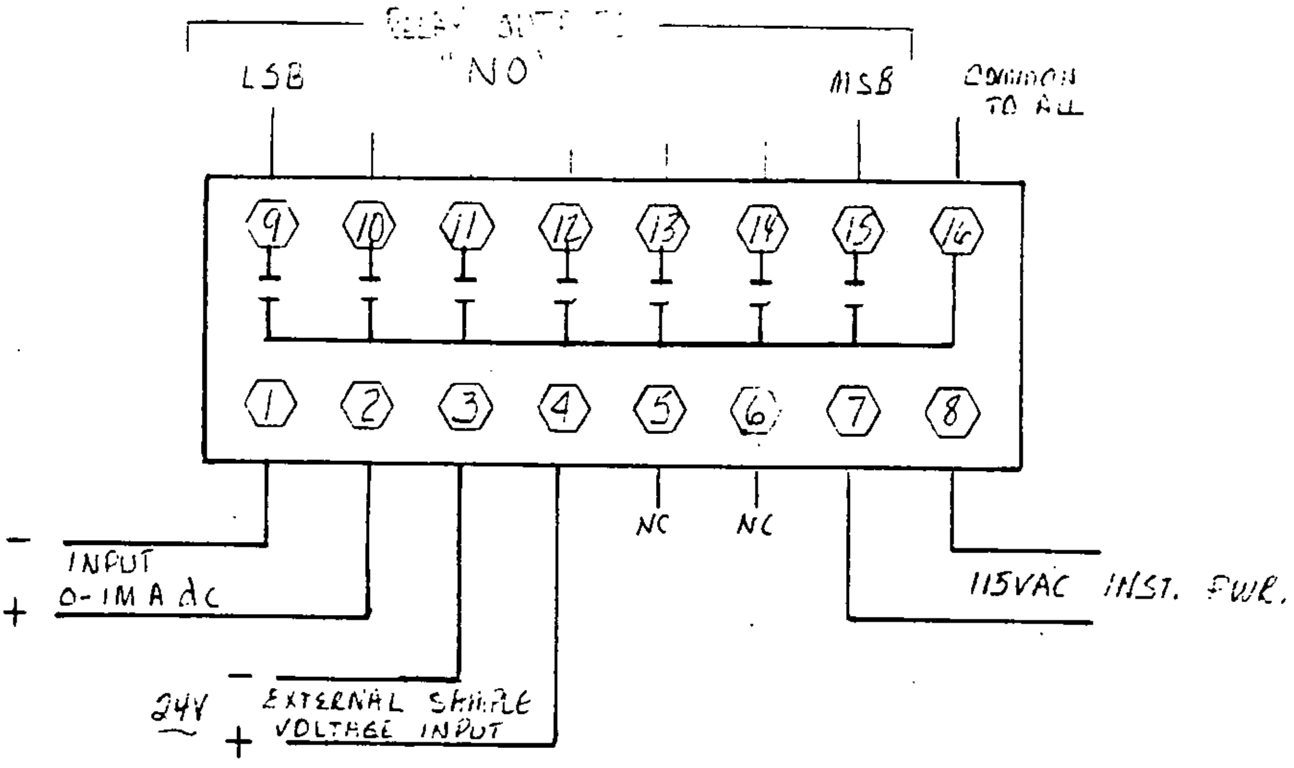
Specifications:

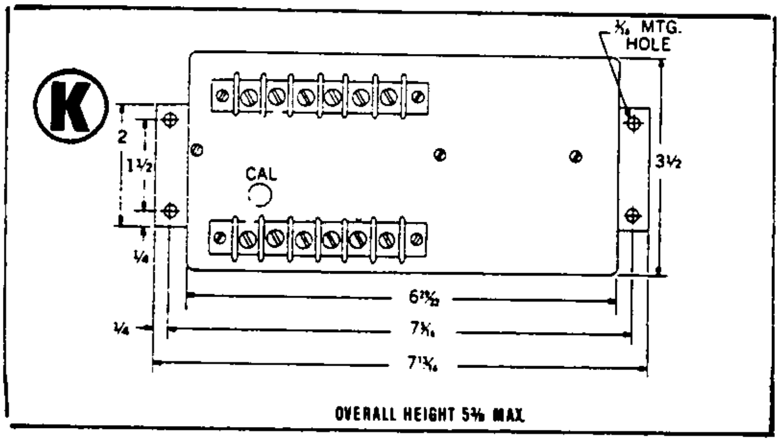
	Model CAD1941
Input:	
Signal	0 to 1 mA dc
Max	0 to 1.2 mA dc
*Load	10K ohm
**External Sample Voltage	24V ± 5V
Sample pulse width	< 900 MSEC for 1 Sec rate
Output:	
Signal	7 bit binary
Relay	7 normally open
Contact Rating	15VA Max., 1A, 50Vdc
Accuracy	± 1.0% RO
Temperature Range	0 to 50°C
Instrument Power Required	115VAC ± 10% 60 Hz

* Note: (1) This input resistor can be changed, via terminal 1 & 2, for direct reading in engineering units. Resistor is internally mounted.

**Note: (2) This input is isolated via photo-coupler.

APPLICATION		REVISION			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED





OVERALL HEIGHT 5⅜ MAX

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:	CONTRACT NO.		OHIO SEMITRONICS INC 1205 Chesapeake Ave Col. OH. 43212
FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±	APPROVALS	DATE	
	DRAWN		CONNECTIONS & DIMENSION DIAGRAMS CAD-1941
MATERIAL	CHECKED D. Miller	11-30-83	
FINISH			SIZE A
			CODE IDENT NO.
			DRAWING NO.
DO NOT SCALE DRAWING			SCALE
			SHEET OF

BISHOP GRAPHICS, INC.
REORDER NO. 20500

Instructions For Type MME Contactor 10, 25, 50, 100 or 150 Amperes, DC 600 Volts, Maximum

I.L. 17071

THE CONTACTOR

Each type MME contactor is a front-connected industrial contactor rated for DC applications up to 600 volts. They are available in several configurations.

This industrial type control is designed to be installed, operated, and maintained by adequately trained people. These instructions do not cover all details, variations, or combinations of the equipment, its storage, delivery, installation, check-out, safe-operation, or maintenance. Care must be exercised to comply with local, state, and national regulations, as well as safety practices, for this class of equipment.

Each structure has a 150 ampere DC continuous rating, but to match the contactor to the load for maximum contact life, the contactor is supplied with either a 10, 25, 50, 100, or 150 ampere blowout coil from the factory. In addition the 10, 25, and 50 ampere versions have different main contact springs and operating coils than the 100 and 150 ampere units. See Table I for identification information.

Each operating coil is designed for continuous duty at full voltage and does not require the insertion of a series resistor after pick-up. The design is such that the contactor will pick-up and seal at 80% of rated voltage when the coil is hot, i.e., at operating temperature. The coil will also stand 110% of rated voltage without burnout. Note that the normal operating temperature of an industrial contactor coil is higher than boiling water, so do not be alarmed by this temperature.

The Type MME 11 has one normally-open and one normally-closed main contact and two operating coils. The normally-closed contact at the bottom will not completely seal until the lower coil is energized. The control circuit must be designed to continuously energize either the top coil or the bottom coil. Both coils must not be deenergized at the same time because the lower main contact does not have adequate contact pressure unless the lower coil is energized.

The MME contactor line is also intended as a replacement for earlier rear-connected contactors Type M and MM. This requires the use of one rear-connection kit 2184A10G08 for each MME contactor. Instructions for the conversion are included in the kit.

TABLE I-CURRENT RATINGS

FRONT CONNECTED TYPE MME CONTACTORS

Contactor Type Identification (Less Coil)	Pole and Contact Arrangement NO = Normally Open NC = Normally Closed	Open 8-Hr. Ampere Rating
MME 01-10	1 NC	10
MME 10-10	1 NO	10
MME 20-10	2 NO	10
MME 11-10	1 NO/1 NC	10
MME 01-25	1 NC	25
MME 10-25	1 NO	25
MME 20-25	2 NO	25
MME 11-25	1 NO/1 NC	25
MME 01-50	1 NC	50
MME 10-50	1 NO	50
MME 20-50	2 NO	50
MME 11-50	1 NO/1 NC	50
MME 01-100	1 NC	100
MME 10-100	1 NO	100
MME 20-100	2 NO	100
MME 11-100	1 NO/1 NC	100
MME 01-150	1 NC	150
MME 10-150	1 NO	150
MME 20-150	2 NO	150
MME 11-150	1 NO/1 NC	150

AUXILIARY CONTACTS

Each MME contactor can accommodate two Type L46 auxiliary contacts. Type MME 11 double-throw contactors (1 NO/1 NC) can mount two L46's per throw. When ordering auxiliary contacts specify Type L46, the mode (Normally-Open or Normally-Closed), and the type designation of the MME contactor on which the auxiliary contact is to be mounted. See Table II for auxiliary contact ratings.

TABLE II - AUXILIARY CONTACTS

L46 CONTACT RATINGS

DC Volts	Make	Break
10-20	10A	10A
20-600	200 VA	200 VA

INSTALLATION

The MME contactor is intended to be mounted on a vertical flat metal panel. The two mounting holes have a ⅜ inch diameter. Use .312" dia. steel mounting bolts with a flat washer against the plastic base and a lock washer under the head. When the contactor is mounted in position, there must not be any grounded, any energized, or any combustible part inside of the minimum arcing clearance (dotted-line shown on Figures 2, 3, 4 or 5) which is the exhaust pattern of the arcbox.

Like most DC contactors, the frame of the Type MME is at line potential when the contactor is energized. Gases and flashes of light from the arcbox can also be hazardous. Make the installation accessible only to authorized and trained personnel.

Before mounting the contactor on the panel, make sure all curcuits on the panel are de-energized. Check Table I to see that the voltage and current ratings of the contactor agree with the application. Next, check the label on the operating coil to see that its rated voltage agrees with the coil supply voltage to the panel. Finally, insure that the auxiliary contacts have the correct electrical function (normally-open or normally-closed) and the correct physical arrangement to agree with the wiring diagram.

After the contactor is mounted to the panel, temporarily withdraw each arcbox by disengaging the flat spring latch on the right side of the arcbox, and pulling the arcbox forward, away from the panel, toward you. The arcbox will be restrained by its polarizing shunt and need not be completely removed. It can be allowed to dangle for the time being.

With the arcbox clear, connect the line cable to the line terminal(s), using a lug for the cable and steel hardware in the clearance hole in the terminal. Refer to Figures 2, 3, 4 or 5 for the location of the .343" dia. or .281" dia. terminal holes on the contactor. Do not use hardware any longer than necessary. Make certain there is ½ inch clearance between the hardware and the mounting panel.

Next connect the load cable to the load terminal at the bottom or center of the contactor, using similar hardware and maintaining at least ½ inch clearance.

With the panel still de-energized, operate the contactor by pushing on the top of the moving armature toward the panel with a screwdriver. The moving system should move freely on its bearing with no mechanical interference or rubbing.

REINSTALL THE ARCBOX BY SLIDING IT BETWEEN THE BLOWOUT IRONS UNTIL IT ENGAGES THE SPRING LATCH AND IS LOCKED. Check the moving armature again by pushing with a screwdriver to make certain the moving system can move freely, both in closing and opening movements.

Make the connections to the coil terminals and the auxiliary contact terminals.

The contactor is now ready for service. Precautions during the first power operation should be in accordance with safety practices appropriate to the application, and should be under the control of authorized and qualified personnel.

MAINTENANCE

This industrial type control is designed to be installed, operated, and maintained by adequately trained people. These instructions do not cover all details, variations, or combinations of the equipment, its storage, delivery, installation, check-out, safe-operation, or maintenance. Care must be exercised to comply with local, state, and national regulations, as well as safety practices, for this class of equipment.

Make certain that the contactor and panel are completely de-energized before attempting any maintenance or repair.

It is recommended that the contactor be examined at regular intervals so that preventive maintenance can be done. The frequency of examination will depend on how many interruptions per hour or per day the contactor must withstand. Ten to twenty operations per hour would suggest weekly examinations; ten to twenty operations per day would indicate examination every three or four months. In the beginning, examination should be relatively frequent until some history has been developed.

ARCBOX INSPECTION

Withdraw the arcbox after unlatching and turn it over so that the inside can be observed. Some erosion, producing a whitish color is normal, as are some streaks of smoke. However, if the erosion produces cavities that might become holes through the arcbox wall, or if the inside is glazed with metal globules or glass-like melted areas, the arcbox should be replaced.

To completely remove the arcbox, it is also necessary to remove the screw securing the end of the polarizing shunt to the frame.

CAUTION: NEVER OPERATE CONTACTORS WITHOUT ARCBOXES LATCHED IN PLACE AND POLARIZING SHUNTS FASTENED TO THE MAIN FRAME.

CONTACTS

It is normal for contacts to show some burning and mechanical abrading. Every time the contactor operates, some material is lost from the contacts. When the contactor has operated so many times (and lost so much material) that the moving and stationary contact faces barely touch each other, then the contacts must be replaced.

The allowance for contact face wear is called "overtravel". When the Type MME contactor is new the overtravel is at full value. When the overtravel has decreased to the minimum acceptable shown in Figure 1 the contacts must be replaced.

After a particularly difficult interruption, a contact may develop beads of metal. Such beads can be removed with a file and if the overtravel is still within limits, the contactor can be returned to service. There is no need to try to file out every blackened pit in a contact.

However, if either contact face is eroded so that the silver alloy is gone and only copper remains, that contact must be replaced even if the overtravel is within limits.

Contact springs generally do not need attention unless they get burned by a bad interruption, or unless they simply wear out mechanically. Do not try to adjust a spring. If it needs attention, replace it. Order replacement contacts and contact springs in kit form, one kit per pole. See Table III.

ARMATURE

The armature uses a knife edge bearing which should outlast the rest of the contactor. It is intended to operate without lubrication so that it does not collect abrasive dust. The only maintenance required is to make certain that the moving armature does in fact move freely without interference or binding.

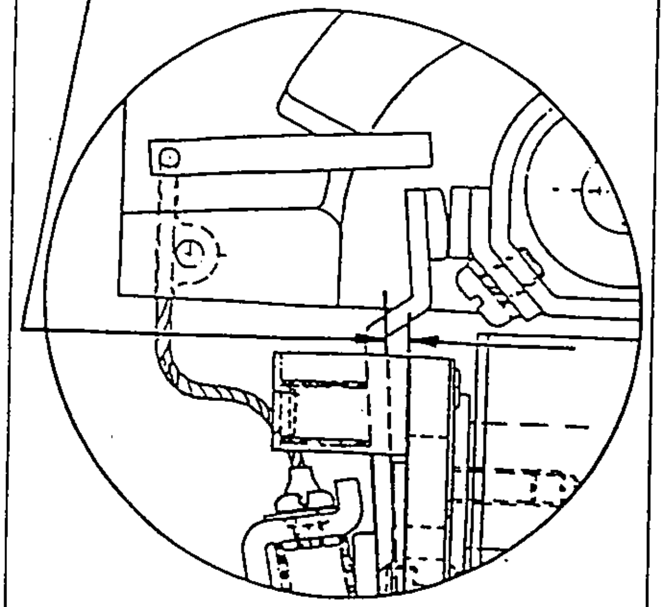
OPERATING COIL

If the operating coil is to be changed or replaced first de-energize the panel and disconnect the coil terminals. Then unlatch the arcbox and withdraw. Next loosen the two bolts holding the arcbox and the moving system, which will then hang from the contactor suspended by the main current shunt. It is then obvious that the pole face screw and pole face can be removed to remove the coil. Keep track of the parts removed and replace them in the reverse sequence with the replacement coil. Make certain when the replacement is complete, that the moving system moves freely and the arcbox is fully installed.

REPLACEMENT DEVICES

Order replacement devices and coils by type designation shown on the name-plate, which is coded as shown in Table I. Specify the coil operating voltage. The contactor type number does not include auxiliary contacts (electrical interlocks), which must be specified separately, by contact arrangement.

Example:
One-Type MME 10-50 with 250 volt DC coil and one normally-open auxiliary and one normally-closed auxiliary.

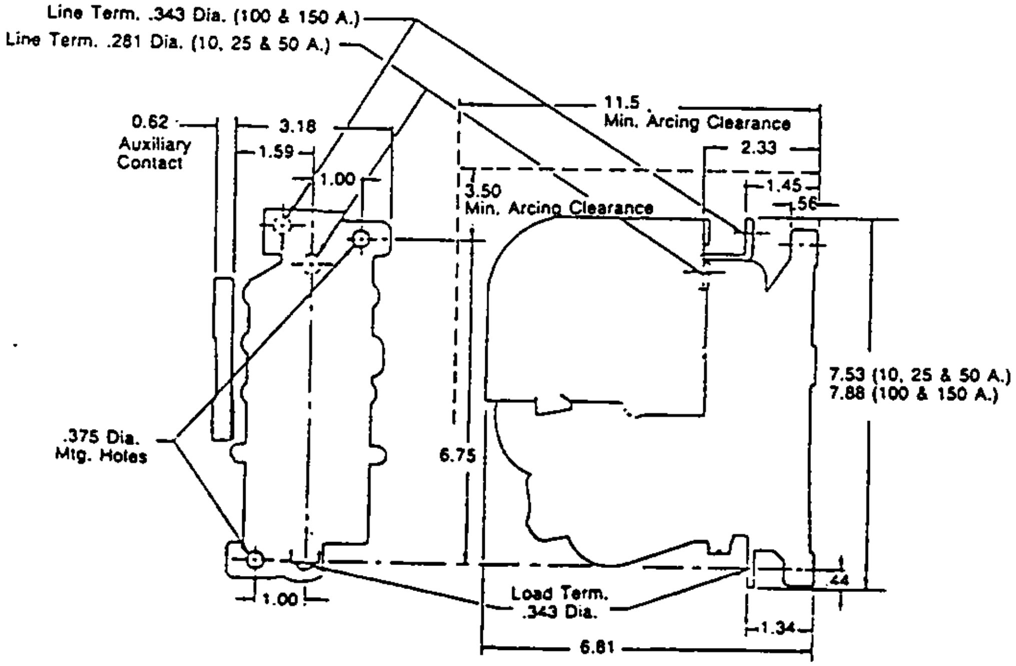


Overtravel Measurement
Approx. .125" new
Replace at .020" min.

Fig. 1 Measuring Contact Overtravel

TABLE III - RENEWAL PARTS

Pole Arrangement	Renewal Part	Renewal Part No.
All	Contact and contact spring kit (1 pole)	2184A10G14
2 NO	Contact Support Kit	2184A20G17
2 NO	Shunt Replacement Kit	2184A20G16
1 NO/1 NC	Shunt Replacement Kit	2184A11G07
1 NO	Shunt Replacement Kit	2184A10G21
1 NC	Shunt Replacement Kit	2184A10G21
2 NO	Armature Kit	2184A20G15
1 NO/1 NC	Armature Kit	2184A11G06
1 NO	Armature Kit	2184A10G19
1 NC	Armature Kit	2184A10G19
All	Coil Mounting Kit	2184A10G20



(2D78700)

Fig. 2 Dimension Drawings (Dim. in inches) of 1 NO Pole MME Contactor

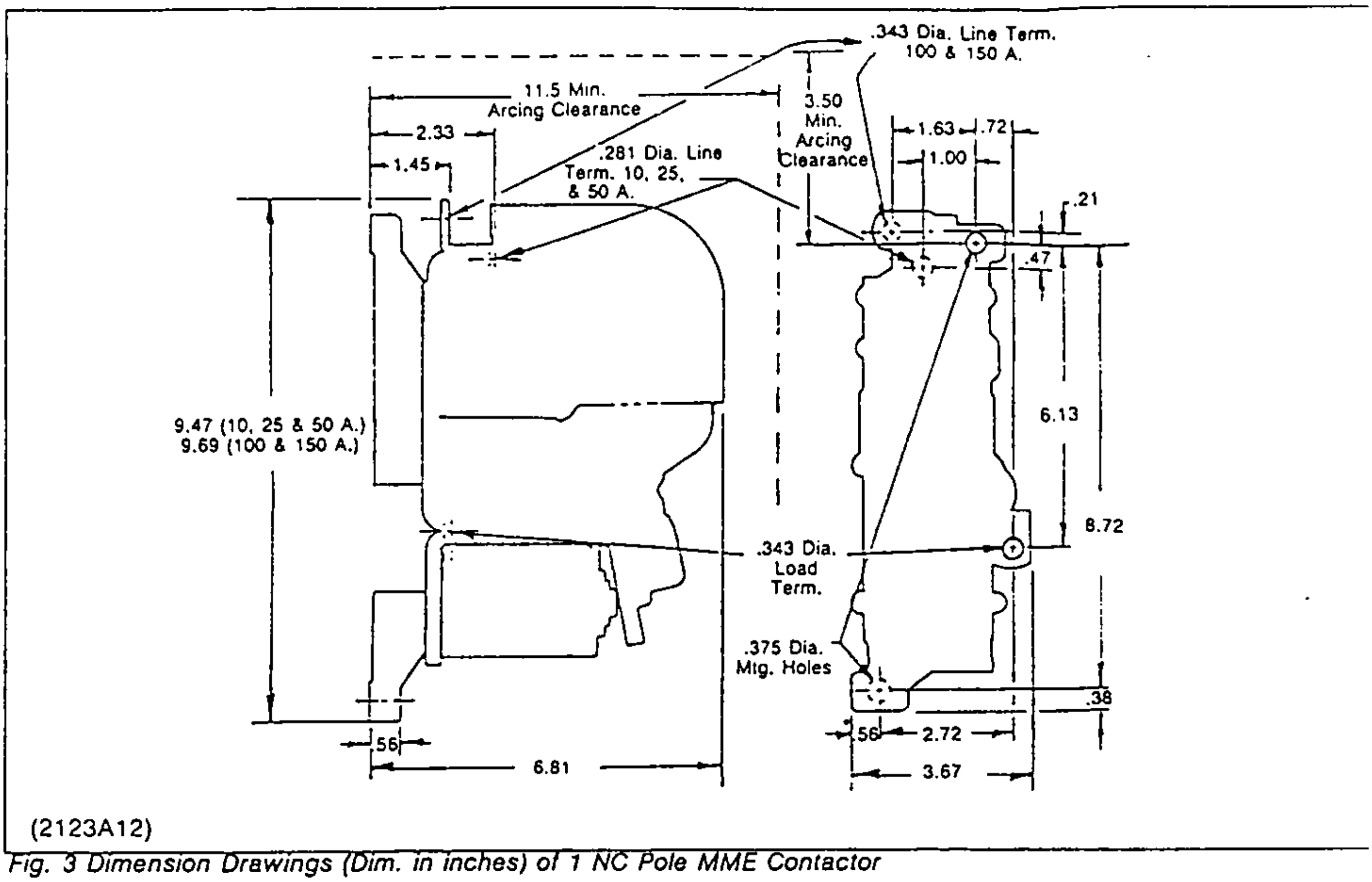


Fig. 3 Dimension Drawings (Dim. in inches) of 1 NC Pole MME Contactor

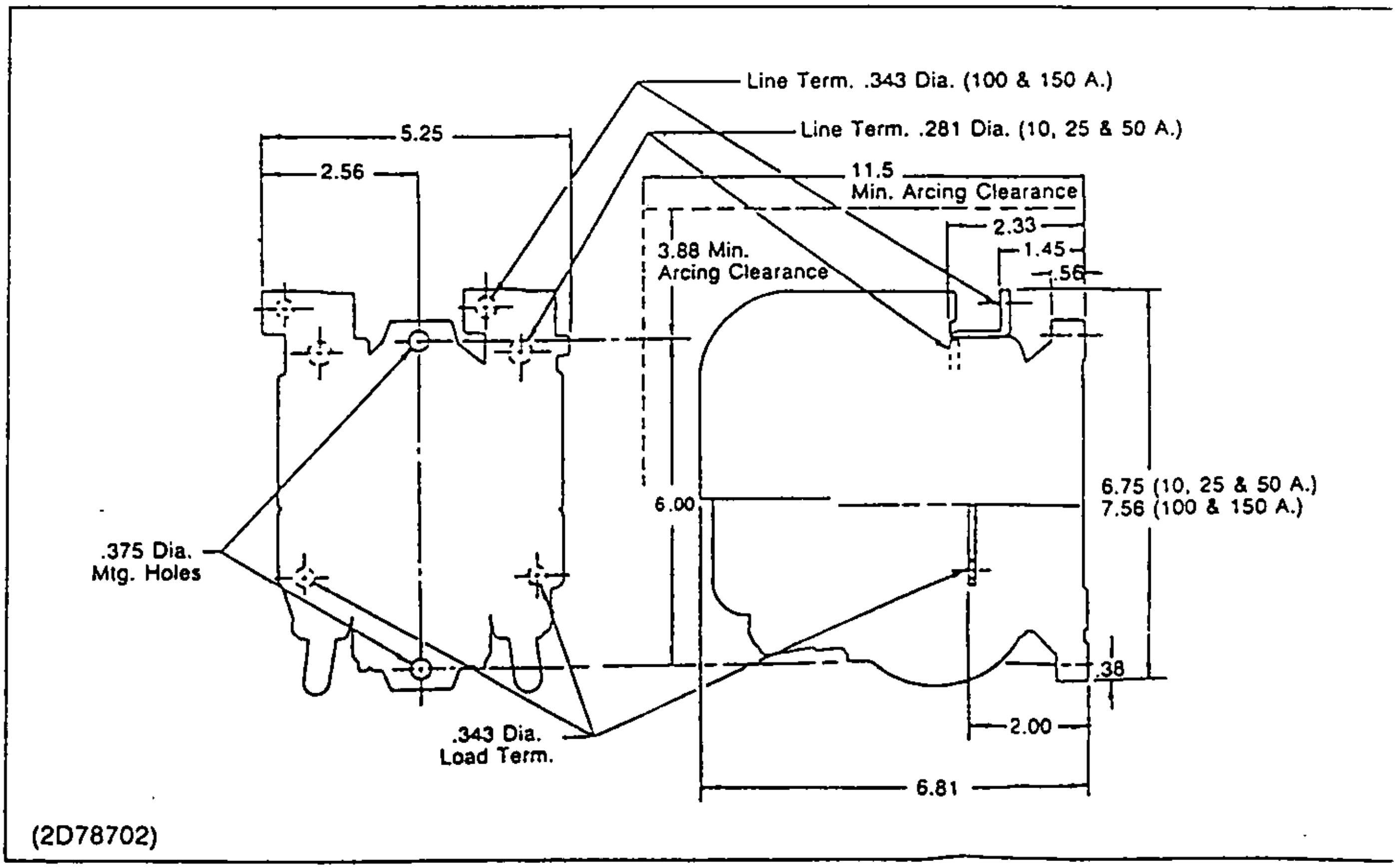


Fig. 4 Dimension Drawings (Dim. in inches) of 2 NO Pole MME Contactor

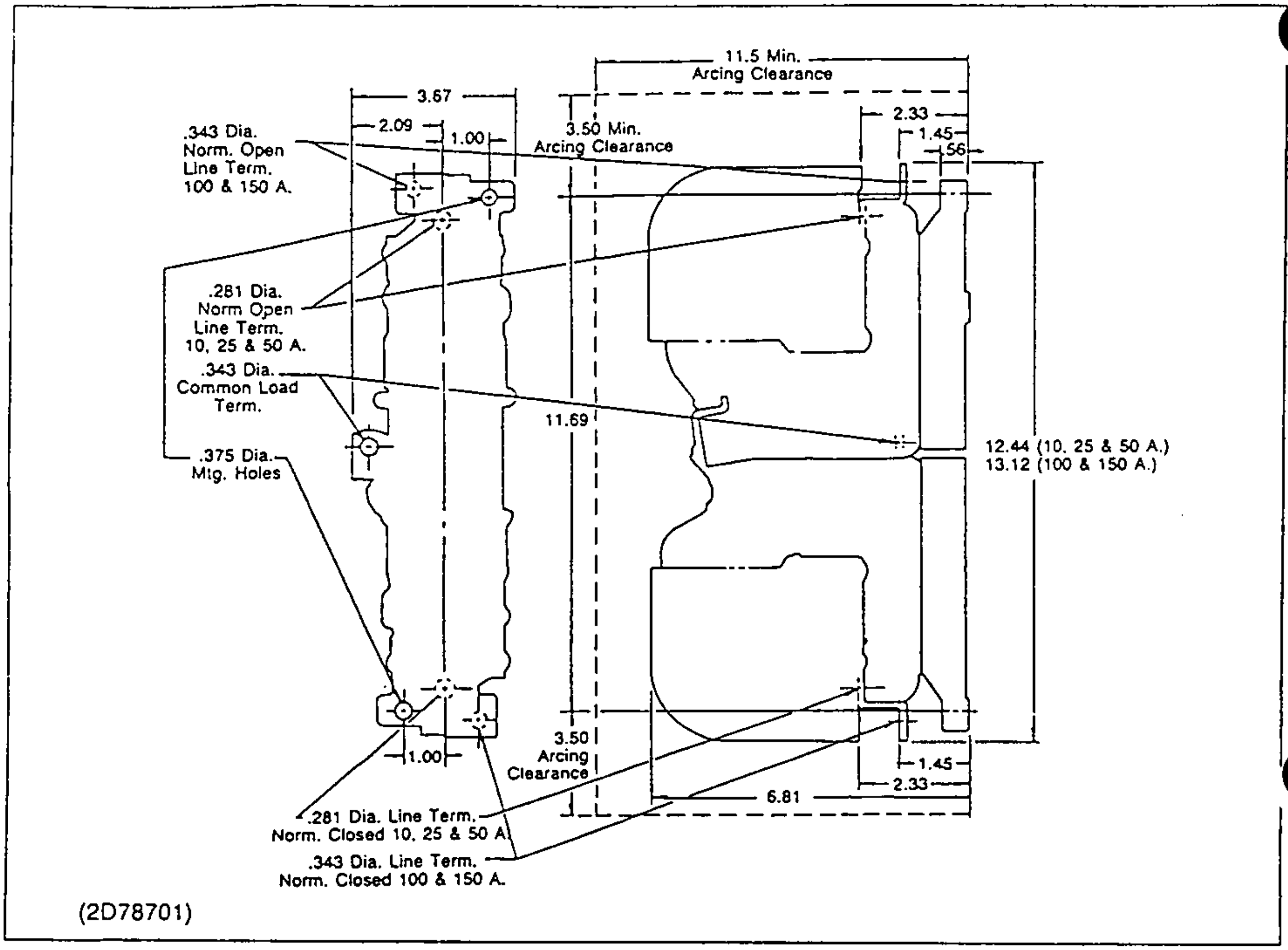


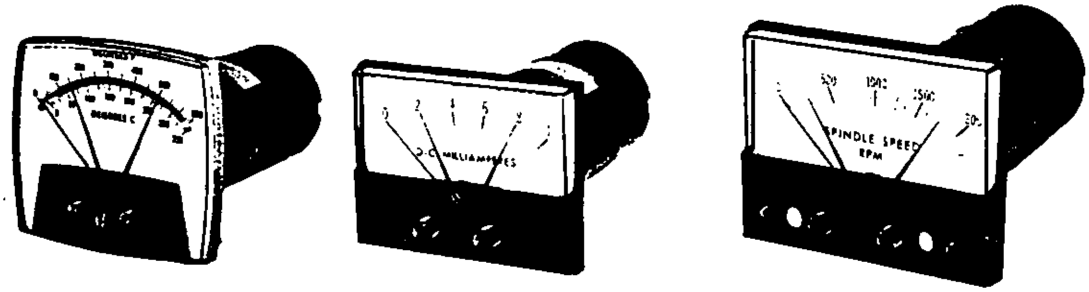
Fig. 5. Dimension Drawings (Dim in inches) of 1 NO/1 NC Pole MME Contactor

LFE CORPORATION
Process Control Division
55 Green Street
Clinton, Massachusetts 01510
(617) 835-1000

INSTRUCTION MANUAL

195 & 196 SERIES METER RELAY CONTROLLERS

955-242
2284



195 SERIES
Dual Setpoint

196 SERIES
Dual Setpoint

196 SERIES
Dual Setpoint
with Manual Reset

Fig. 1 195 and 196 SERIES Meter Relays

INTRODUCTION

These instructions cover the installation of 195 Series Meter Relays in three sizes and 196 Series Meter Relays in two sizes.

195 and 196 Series Meter Relays consist of two separate units, an indicator setpoint unit and a control unit. The indicator setpoint unit is basically an electric indicating panel instrument, to which has been added control point indication and initiation. The indicator setpoint unit has control point adjustment knob(s), control point indication pointer(s), light sensor(s), lamp and light shield. The control unit consists of a DPDT load relay for each setpoint and supplies power to the lamp and light sensor(s) in the indicator setpoint unit.

OPERATION

Operation is based on the characteristics of a light-sensitive solid-state sensor, which is effectively CLOSED with light incident upon it and is effectively OPEN when shielded from the light. One of these sensors is attached to each setpointer and is connected to a transistorized switch circuit in series with a load relay coil. The light shield, carried by the indicating mechanism, controls admission of light to the sensor, causing the load relay(s) to be energized or de-energized strictly in accordance with POSITION of the indicating pointer with respect to the setpointer(s).

For ON/OFF control action (automatic reset), as shipped from the factory, the sequence of operations is as follows: The setpoint(s) (low = blue, red = high) are positioned at desired points on the scale by use of knobs located on the indicator front. With power connected to the control unit, operation of the load relay(s) is in accordance with POSITION of the indicating pointer as shown in Table I.

TABLE I
MODE OF OPERATION OF RELAY(S)

INST. POINTER RELATIVE TO SETPOINTS	HIGH (RED) SETPOINT		LOW (BLUE) SETPOINT	
	LIGHT-SENSOR	LOAD RELAY	LIGHT-SENSOR	LOAD RELAY
Downscale (LEFT) from Setpoint(s)	Light	Energized	Dark	De-energized
Between Setpoint(s)	Light	Energized	Light	Energized
Upscale (RIGHT) from Setpoint(s)	Dark	De-energized	Light	Energized

In addition to DC and AC (rectifier) measurement models, meter relays can be supplied as pyrometers. These pyrometers have bimetallic cold-junction compensation.

MANUAL RESET

Front Panel - The 4½-inch size 196 Series Meter Relay can be supplied with built-in manual reset push buttons on the face of the instrument. The unit shown in Fig. 1 has a double setpoint; however, a single setpoint (high or low) can be supplied also. The manual reset provides an alarm light adjacent to the push button which lights when the setpoint is tripped. The alarm light is extinguished and load relay is energized when the manual reset push button on the front panel is pressed and the indicating pointer is in a position to admit light on the sensor to provide the control action indicated in Table I.

External (User Supplied) - All sizes of 195 and 196 Series Meter Relays can be provided with manual reset action by the connection of user-supplied, momentary contact switch(es) to the appropriate terminals and by the removal of jumper(s) as indicated in Fig. 2. Thus, when the relay is tripped, the load relay cannot be re-energized again until (a) the indicating pointer is in a position to admit light to the sensor per Table I and (b) the external (normally open) momentary push-button switch is pressed.

IMPORTANCE OF PERIODIC OPERATIONAL CHECKS

Operational reliability can be increased by periodic testing of the meter relay as described below.

1. The setpoint tripping function should be tested periodically. Each setpoint on a two-set unit should be tested separately since each setpoint has its own circuitry. The simple test consists of manually rotating each setpoint beyond the instrument pointer to determine if the output relay contact opens or closes, as it should.

2. Determine that the mechanism pointer drops freely to 0 and returns to its original scale position without any hesitation or signs of sticking by removing and returning the input signal to the instrument.

The frequency of such a periodic operational check should be determined by the user, based on his application and the potential impact of a meter relay malfunction. An instrument which fails to meet the above checks should be removed for service by qualified instrument service personnel.

The adjustment potentiometers on the small transistor switch circuit board inside the indicator setpoint unit are sealed at the factory and should not be adjusted.

CAUTION

> Improper adjustment of the potentiometers could result in setpoint trip failure (relay continuously energized) regardless of pointer position.

SPECIFICATIONS

SETPOINT COINCIDENCE ERROR: ±2% F.S.

REPEATABILITY: 0.3%, F.S.

CURRENT INPUT SIGNALS: For measured currents above 20 mA AC, an auxiliary transformer must be used, except for models with an internal 5 amp current transformer. Digits 5 and 6 in the part number designate internal or external transformer. LS indicates internal current transformer. HF indicates external transformer required.

VOLTAGE INFLUENCE: 0.75% max. change with 10 volt change (from 117VAC reference)

INDICATING POINTER TRAVEL: The indicating pointer will indicate accurately above or below either setpoint.

LOAD RELAY:

a. Three-pole double-throw for each setpoint. Only two poles/setpoint available for external connections. (See external connections, Fig. 2.) Only one pole/setpoint available on self-contained manual reset models.

b. Contact Rating: 5 amps AC non-inductive at 120V; 5 amps DC non-inductive at 28V.

CAUTION

The output relay contacts are silver and silver cadmium oxide for reliable operation in non-inductive circuits up to 5 amps at 120VAC or 28VDC. Normal energy levels of voltage and current aid in breaking down non-conducting contact surface films. Therefore, use of the meter relay contacts is not recommended at low energy levels such as millivolt signal circuits or logic circuits. Contact performance will vary depending on meter relay environment.

MOUNTING POSITION:

Indicator Setpoint Unit:

Standard: Scale vertical
Optional: Any with special calibration

Control Unit: No position influence

AC POWER SUPPLY FOR CONTROL UNIT: (See note below.)

Minimum	Nominal	Maximum
107V, 50/60Hz	117V, 50/60Hz, 7.0 VA Max. for either single or double setpoint unit	127V, 50/60Hz

NOTE: If the load being controlled causes a voltage drop of more than 2 volts in the AC voltage supply for the meter relay, the meter relay supply should be taken from a different source to prevent "hunting" of the control system.

CONTROL POINT BAND: Less than 1% F.S.
FREQUENCY INFLUENCE: 0.3% max. change, 60Hz to 45Hz or 60Hz to 65Hz
CONTROL ACTION: Automatic on/off action (Automatic Alarm Reset). If alarm or limit control action (Manual Alarm Reset) is desired, the user can provide it be removing jumper wires and adding momentary-contact or push-button switches as shown in Fig. 2. If built-in manual reset option is supplied and automatic reset in desired, connect jumpers across Terminals 1, 2 and 3 per Fig. 2.
LAMP: Expected life five years. Output relay becomes de-energized on lamp failure and setpoint trip does not operate. This failure is normally self indicating.
DIELECTRIC TEST: Live parts to face and panel--2,600 volts RMS.

INSTALLATION

MOUNTING

NOTE: All drilling of the panel should be completed before the unit is mounted. (See Figures 6, 7, 8, 9, 10, 11 and 12)

195 and 196 Series Meter Relays are sturdily constructed and will withstand reasonable amounts of vibration and handling. If panel vibration is enough to cause false pointer indication, or if severe mechanical shock is expected in operation or shipping, mount the control unit separately to reduct the effect of the length and weight of the combined assembly.

CAUTION

> Control Unit identity number must be as noted on the setpoint unit rating plate.

The indicator setpoint unit contains its own shielding and can be mounted on magnetic or nonmagnetic panels without special calibration.

The 3½- and 4½-inch sizes may be mounted as a unit (see Figures 6, 7, 9, 10, 11 and 12) or the control unit may be mounted separately from the indicator setpoint unit. (See Fig. 8 for separate mounting of the control unit.) The 2½-inch size (195 Series only) requires separate mounting of the control unit with a bracket and a connection cable, which are furnished with this size. (See Fig. 8.)

ACCESSORIES FOR OPTIONAL REMOTE CONTROL UNIT

Accessory kits for installing the control unit remotely are available:

NOTE: Kits described below cannot be used on meter relays with self-contained manual resets.

Kit, Cat. No. 1125-426 - This kit contains plug, socket, wiring connection diagram, bracket and hardware for the meter relay. The user must supply and construct the cable of the desired length by soldering the insulated cable leads to plug and socket. The wire gage of the cable must be selected to provide each conductor with a resistance of 0.1 ohm or less. The following table can be used as a guide for this 0.1 ohm-per-lead determination.

AWG SIZE	MAX. CABLE LENGTH
18	19 feet
20	12 feet
22	7 feet
24	4.5 feet
26	3.0 feet

Kit, Cat. No. 1125-425 - This kit contains a six-foot cable with plug and socket connectors soldered to cable, plus bracket and hardware. (This kit is furnished as standard equipment with 2½-inch meter relays.)

CONNECTIONS

All wiring must comply with local codes, regulations and ordinances. No internal fusing is provided in the meter relay.

DO NOT MAKE CONNECTIONS WHILE POWER IS APPLIED TO EITHER THE POWER SUPPLY TERMINALS, THE CONTROL RELAY TERMINALS OR THE MEASUREMENT TERMINALS.

INDICATOR SETPOINT UNIT

Connections to the circuit being measured are made at terminal studs on the back of the case of the indicator setpoint unit. (See Fig.4.) The left-hand stud (rear view) is always positive. The contact surface of nuts, washers and cable terminals must be thoroughly clean to insure good contact.

Connections between the indicator setpoint unit and the control unit are made through a built-in connector and socket when the control unit is mounted "piggy-back" on the indicator setpoint unit (3½- and 4½-inch size) or by a prewired cable assembly for the 2½-inch size or when the control unit is mounted remotely with other sizes.

AUXILIARY CURRENT TRANSFORMER

All 2½-inch meter relays and some other models with 20 mA AC rating require an auxiliary current transformer.

CAUTION

> These models must not be connected without the auxiliary current transformer.

The transformer (Part No. 2062-150) is rated for 20 mA output with 5 amp input with a burden of 2.5VA. See Figures 13 and 16 for connections and dimensions. Models requiring this transformer are identified by HF in digits 5 and 6 of the part no. (example V3-12HF-CD00).

Other models have an internal 5 ampere transformer. These models do not require the auxiliary current transformer (example - Part No. V3-12LS-CD00).

CONTROL UNIT

Terminals for the 117 VAC, 60Hz power supply for the double-pole, double-throw relays (one per setpoint) and for the alarm or limit control action are on the back of the control unit. Each terminal is supplied with a No. 6-32 pan head machine screw. (See Figures 2 and 3 for terminal layout.)

The relay terminals are entirely passive and are completely isolated from either the measured circuit or the power supply circuit. (See Table I and Fig. 2 for relay operation.)

ADJUSTMENTS

The following zero adjustments may be necessary in some cases due to a shift in zero position because of shock in transportation. Also, pyrometers must be adjusted for total thermocouple resistance.

The meter relay should be in its operating position when any such adjustment is made ("nominal" voltage is power supply voltage identified on rating plate).

Ammeters and Voltmeters

1. Zero on Scale - Check mechanical zero; adjust pointer to zero with zero signal applied.
2. Suppressed Zero - Apply end-scale signal and adjust pointer to correct indication.

Pyrometers

1. Adjustment of Thermocouple Resistance

NOTE: Total thermocouple resistance may be equal to or less than the lead resistance printed on the scale of the indicator setpoint unit. A small resistor is mounted on the back of the case of the indicator setpoint unit. This resistor is connected in series with the thermocouple and its resistance must be adjusted until the resistance of the thermocouple plus resistor is equal to the lead resistance printed on the scale of the indicator setpoint unit. (See Fig. 4.)

Method of Adjustment

Connect negative (-) thermocouple wire to the smaller of the two terminals which support the resistor. Connect an ohmmeter to the larger of the two terminals, which support the resistor, and to the positive (+) thermocouple wire.

DO NOT connect the positive (+) thermocouple wire to the instrument until resistance adjustment is complete.

The resistor is a double wound, pull off style of approximately 10 ohms. Wire can be removed from the body of the resistor without unsoldering. Resistance of the thermocouple-resistor combination is reduced by unwrapping the looped end of wire from the resistor and shorting between the wires. Continue to remove wire and short between the wires until the resistance of the thermocouple and resistor equals the resistance specified on the scale.

Connect the positive (+) thermocouple wire to the positive (+) terminal of the indicator setpoint unit.

2. Zero Adjustment

a. If meter relay has no T/C break protection, de-energize control unit, disconnect T/C (leave input circuit open), and adjust instrument zero adjustor until pointer indicates ambient temperature; then T/C can be reconnected and control unit energized.

b. If meter relay has T/C break protection, connect T/C to appropriate terminals, but expose T/C to ambient temperature only, and energize control unit for one-half hour; then, adjust instrument zero adjustor for instrument pointer indication of ambient temperature, if necessary.

NOTES: FOR PYROMETERS WITH T/C BREAK PROTECTION

1. With or without T/C connected, and with control unit de-energized, instrument pointer will be off scale below zero. DO NOT adjust zero adjustor.
2. With T/C disconnected and with control unit energized, instrument pointer will be beyond full-scale mark. DO NOT adjust zero adjustor.

Adjustment of Control Point

This adjustment is made using the knob(s) mounted on the front of the indicator. The setting of the control point(s) is indicated by the position of the setpointer. Control action will occur as the indicating pointer passes over the setpointer(s) scale position.

The setpoint(s) may be adjusted from zero to full scale and do not interfere with the indicating pointer. Double setpointers may be positioned to within two angular degrees of each other which is approximately 2% of full scale. Unless otherwise specified on the order, the operation of the setpoints may overlap when the setpoints are brought to their minimum mechanical distance apart.

For best accuracy, allow at least ten minutes warm-up (with lamp energized) before making final setpoint adjustment. This improves the accuracy approximately 0.5%. To check setpoint accuracy, the nominal supply voltage must be used.

MAINTENANCE

CAUTION

DO NOT REMOVE RED LABELS OR USE METALLIC PROBES TO ADJUST CONTROL POINT THROUGH HOLES IN THE SIDE OF INDICATOR SETPOINT UNIT (FRONT UNIT). INTERNAL COMPONENTS MAY BE AT DANGEROUS POTENTIALS. THIS ADJUSTMENT SHOULD BE DONE BY FACTORY OR AUTHORIZED REPAIR PERSONNEL.

To clean the plastic window, wash it with soap and water. To remove grease or oil, use kerosene sparingly. DO NOT use acetone, benzene, carbon tetrachloride, fire-extinguisher fluids, lacquer thinners, or window sprays containing these solvents since they will smear or soften the window.

Wipe the window periodically with a clean, damp chamois. Do not rub with a dry cloth as this is likely to cause scratches and to build up an electrostatic charge which will cause erroneous readings. After cleaning, an antistatic agent should be applied to the window to neutralize any electrostatic charges.

PARTS REPLACEMENT

The 195 and 196 Series Meter Relays utilize a special lamp with leads attached to the lamp and lamp holder assembly (LFE Part No. 1207-246). These replacement parts can be ordered through any authorized LFE distributor or modification center. The lamp is selected and adjusted in the lamp holder in the factory and substitutions should not be made.

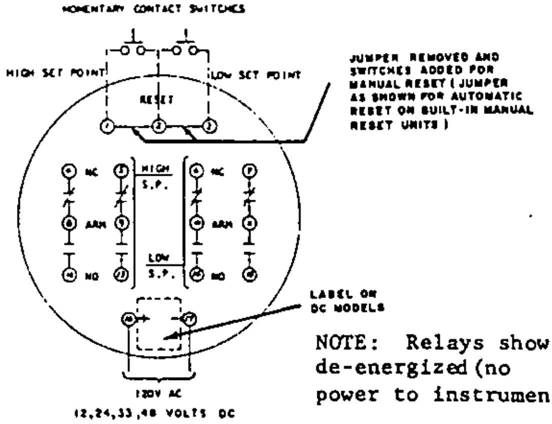
In the event of lamp failure, the lamp assembly can be replaced when the control unit is detached from the rear of the indicator setpoint unit, or the cable plug from the remotely located control unit is disconnected. Then, the lamp-access plate (see Fig. 4) must be removed (screws are beneath adhesive labels) to expose the lamp holder which can be pulled out.

PART NO. 1207-246 LAMP AND HOLDER

The Part No. 1207-246 lamp has been fixed in the lamp holder at the factory such that the filament will be in the correct position when the keyed assembly is inserted in the indicator setpoint unit. Make sure the lamp-lead terminals are engaged by the screws when the lamp access cover is replaced. (NOTE: If relay operation is not within ±2% of setpoint index, the lamp holder position must be rotated 180°.)

REASSEMBLY

After the new lamp assembly has been installed, make sure the lamp access plate is replaced (and screws are tight) before cable plug from remotely located control unit is reconnected, or control unit is reassembled on rear of indicator setpoint unit.



NOTE: Relays shown de-energized (no power to instrument)

Fig. 2 Control Unit External Connections

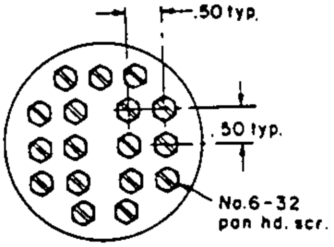


Fig. 3. Rear view of control unit showing spacing of screw-type connections.

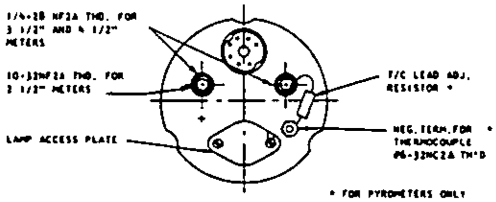


Fig. 4 Typical rear view of indicator setpoint unit

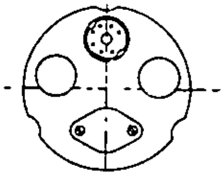
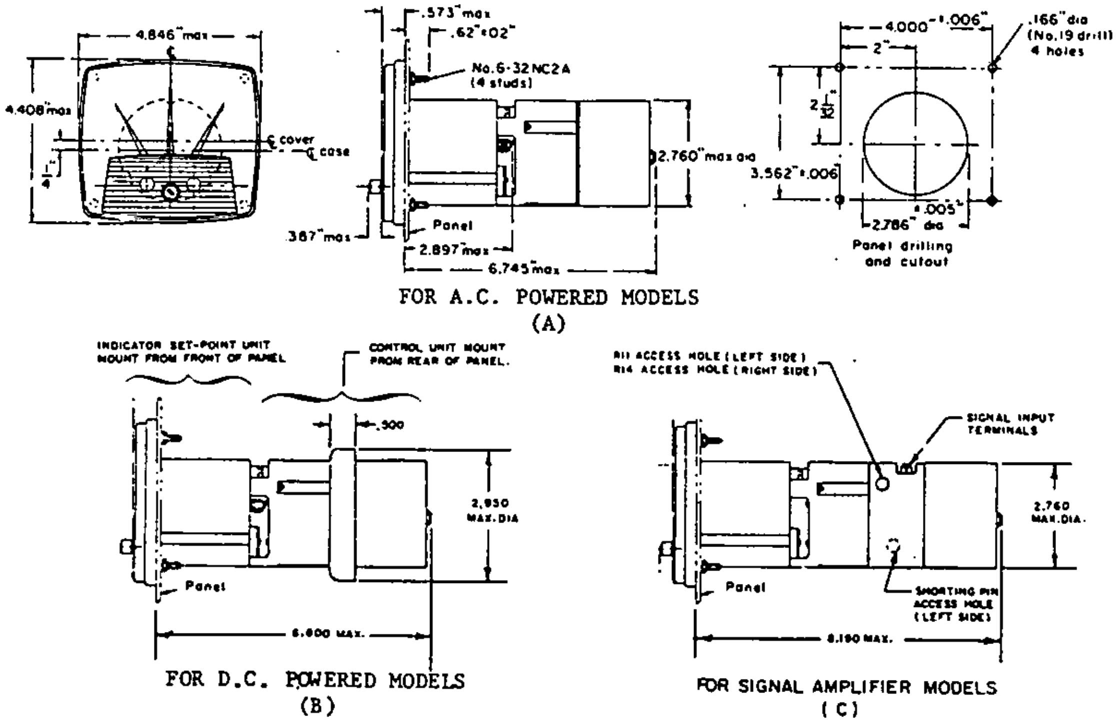


Fig. 5 Typical rear view of indicator setpoint unit



(NOTE:— OUTLINE DIMENSIONS FOR D.C. MODELS AND SIGNAL AMPLIFIER MODELS APPLY TO ALL SIZES OF METER RELAYS)

Fig. 6 195 SERIES Meter Relay, 4½-inch, with control unit rear mounted

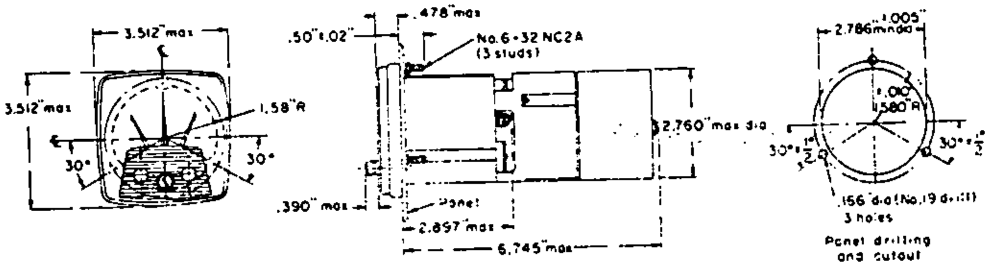


Fig. 7 195 SERIES Meter Relay, 3½-inch, with control unit rear mounted

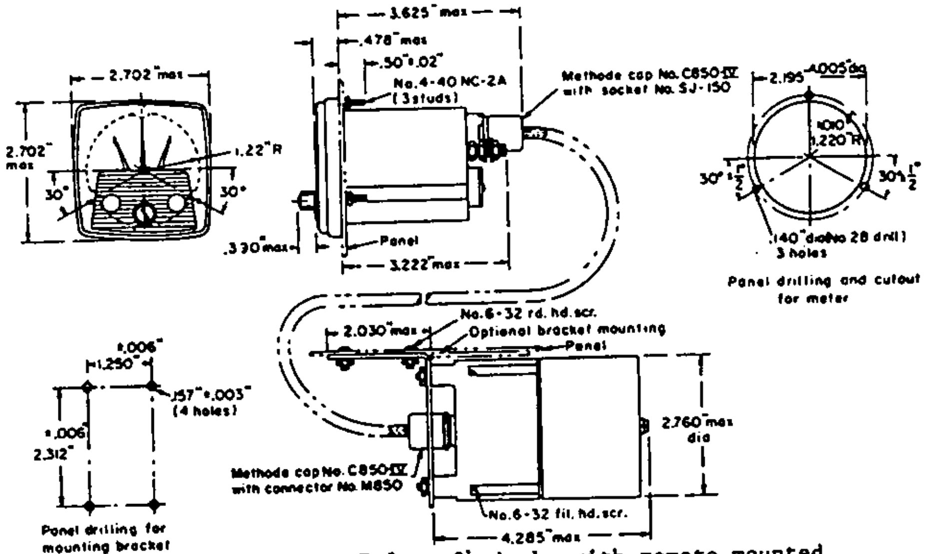


Fig. 8 195 SERIES Meter Relay, 2½-inch, with remote mounted control unit due to small meter size. Remote mounting is the same for all 195 and 196 SERIES if desired.

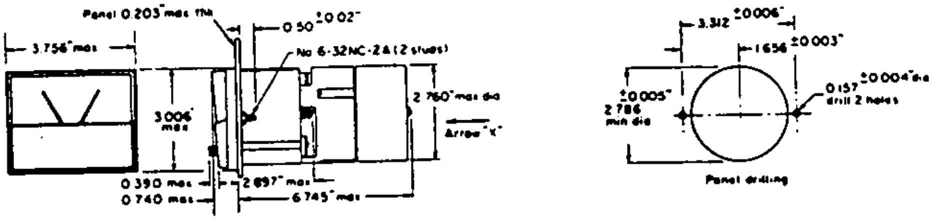
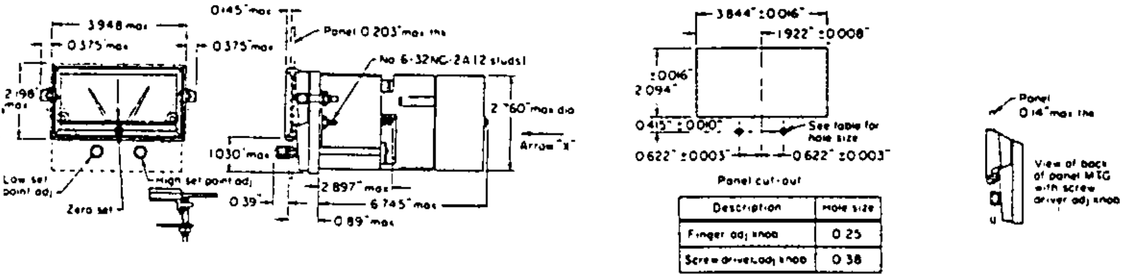


Fig. 9 196 SERIES Meter Relay, 3½-inch, front mounted



Description	Hole size
Finger adj knob	0.25
Screw driver adj knob	0.38

Fig. 10 196 SERIES Meter Relay, 3½-inch, window mounted

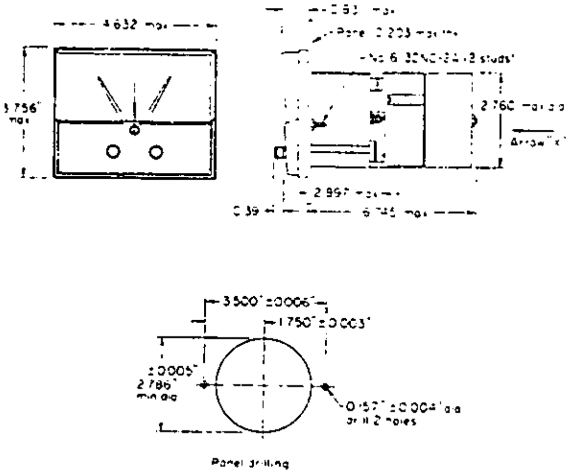


Fig. 11 196 SERIES Meter Relay, 4½-inch, front mounted

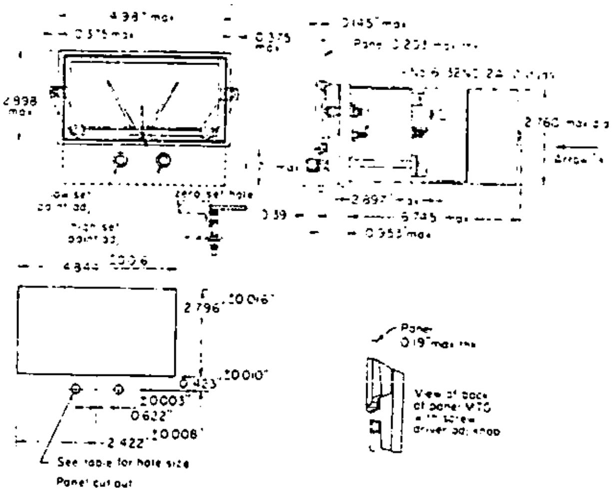
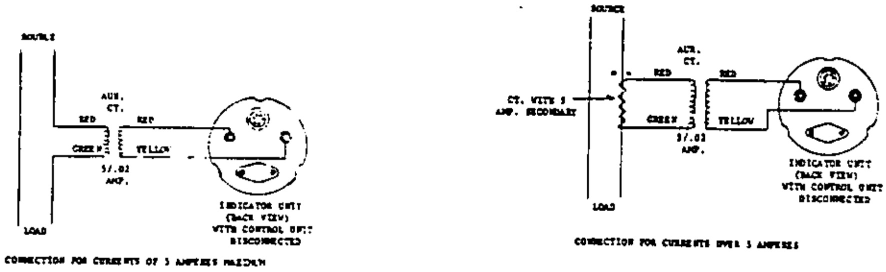


Fig. 12 196 SERIES Meter Relay, 4½-inch, window mounted



NOTE:
1. AUX. CT. 5/.02 AMPERES SUPPLIED WITH TYPE 196 METER RELAY.TO BE MOUNTED BY USER.
2. INDICATOR UNIT RATED 0-.02 AMPERES AC FULL SCALE.
3. AVOID OPEN SECONDARY WHEN PRIMARY IS ENERGIZED

Fig. 13 External connections for Meter Relay with current transformer

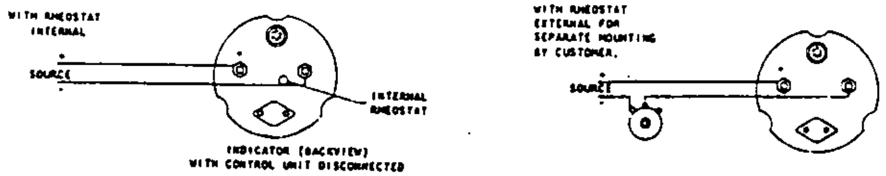


Fig. 14 External connections for Meter Relay with rheostat

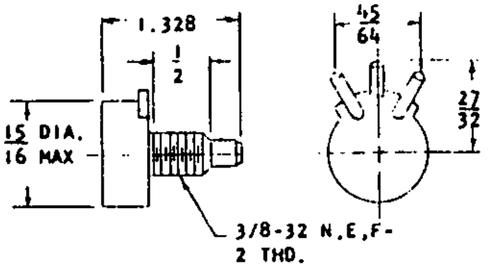


Fig. 15 External rheostat for Meter Relay

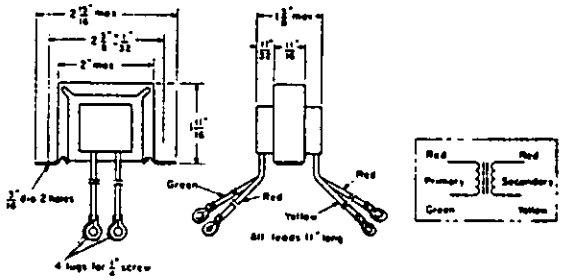


Fig. 16 Step-down current transformer for Meter Relay

WARRANTY

LFE Corporation warrants equipment of its manufacture against defect in material and workmanship for a period of one year from date of shipment. LFE Corporation's obligation under this warranty is expressly limited to the repairing or replacing at its factory or at any authorized repair station of equipment returned provided that (a) LFE Corporation is promptly notified in writing by the Buyer upon his discovery of a defect, (b) Upon receipt of written authorization from LFE Corporation, said defective equipment is returned as directed, with transportation charges prepaid by the Buyer and (c) LFE Corporation's examination of such equipment discloses to its satisfaction that the defect exists and was not caused by negligence, misuse, improper installation, accident or unauthorized repair or alteration by the Customer.

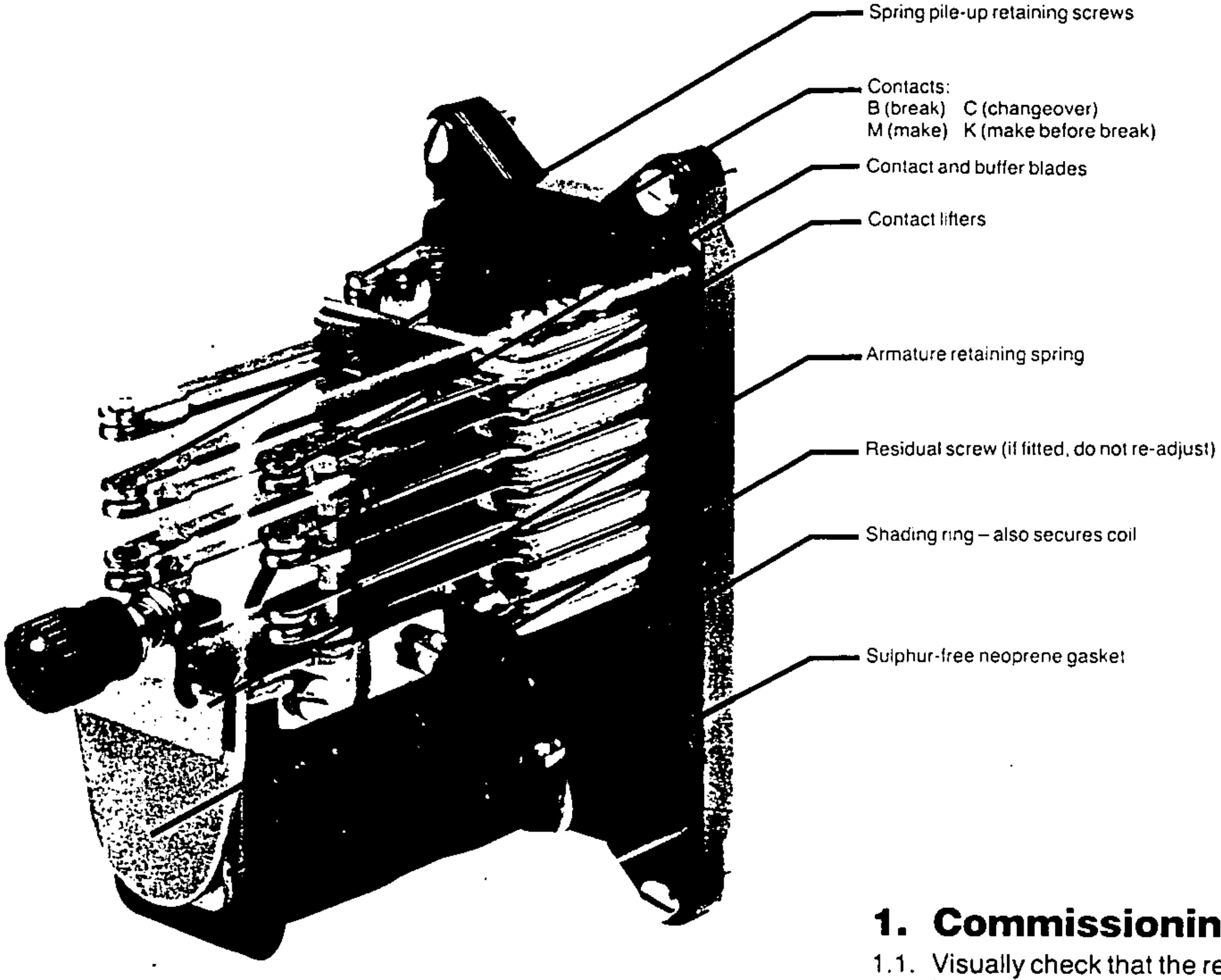
LFE Corporation shall not be bound by any terms, conditions, representations or warranties, express or implied, which are not stated herein.

SERVICING/MODIFICATION

If repair is required, the instrument should be adequately packed with a brief note describing the observed problem and shipped prepaid to the nearest Modification Center or Repair Dept., LFE Corporation, 11655 Chillicothe Road, Chesterland, Ohio 44026.

RELAYS – D2600 plug-in system

Commissioning and Maintenance Instructions



RELAYS MUST NOT BE PLUGGED INTO OR REMOVED FROM THEIR SOCKETS UNLESS THE PROTECTIVE COVER IS FITTED.

1. Commissioning

1.1. Visually check that the relay has not sustained damage in transit.

1.2. Check cover is properly seated on gasket and undamaged.

1.3. Check relay details are to specification,
i.e. coil voltage
contact type and build-up
fouling pin (FP) arrangement.

2. Cautionary notes

2.1. Handling of relays.

Handling the relay without the cover can damage the contact springs and is dangerous if the relay is plugged into a live socket.

To remove a relay from the socket, move the relay gently from side to side, not up and down.

2.2. Removing covers.

2.2.1. Removal and replacement of the cover must be carried out with extreme care to avoid damage to the relay.

2.2.2. Always replace the cover.

Leaving the cover off, particularly during installation, can lead to problems at a later date due to foreign matter entering the relay and finding its way between contacts.

2.2.3. Incorrect replacement of covers.

Relays with blow-out magnets (type D2600/B) have holes in their covers to prevent the accumulation of the gases produced by arcing. Covers for other D2600 relays do not have these holes. It is important to see that covers are not mixed.
Care should also be taken when replacing covers, to see that the neoprene gasket around the base is correctly positioned and that the rubber washer is in place on the fixing screw.

2.2.4. Solvents or oils must not be applied to the cover.

2.3. Contact isolation.

Should it be necessary to isolate contacts, for example, during testing, then synthetic resin-bonded paper (SRBP) no thicker than 0.6mm or a similar lint-free material should be used. Great care should be exercised when inserting or removing the material.

2.4. Sockets used as test points.

With the relay removed, the socket may be used as a test point. However, care must be taken not to damage the contacts by inserting a test prod greater than 0.08mm (0.032 in).

It is recommended that plug blades (D.2608) as fitted to the relays be used as test prods.

3. Preventive maintenance

Under normal operating conditions no maintenance is necessary.

Clifford & Snell relays have considerable built-in safety margins and will give years of trouble-free service when operated within the specified limits.

If the relay is functioning satisfactorily do not attempt to clean away blackening that may occur in the region of the contacts or on the inside of the cover. This is simply the result of hard use with some contact arcing.

4. Contact cleaning

Contact cleaning is unnecessary unless actual failure of the contact to operate has been observed.

Cleaning should be by use of a contact cleaning tool, e.g. a leather-faced spatula.

Abrasive materials must NOT be used.

5. Contact blade adjustment

This procedure is only to be used as an emergency measure when failure of the relay has been observed and no spare unit is available.

Contact blades should only be stressed by stroking, they must NEVER be bent or kinked. The limit of travel of the blade is set by adjusting the backing strip, this is directly above or below the contact, depending upon the contact action.

The contact setting values are as follows:

(a)	Minimum pressure between two made contacts	25gm
(b)	Minimum back pressure against push rods	5gm
(c)	Minimum wipe at the contact surface	0.25mm
(d)	Minimum contact gap	0.812mm

After adjustment, visually check contact movement and operation.

N.B. THIS PROCEDURE IS AN EMERGENCY MEASURE AND THE FAULTY RELAY SHOULD BE REPLACED AT THE EARLIEST OPPORTUNITY.

6. Repair

Defective relays should be replaced with a spare and the faulty unit returned for repair to:

Clifford & Snell Ltd.,
512 Purley Way,
Croydon CR0 4NZ.

7. Technical data

Technical data applicable to the D2600 Relay range is described in publication C90.2.

Publication C880.2

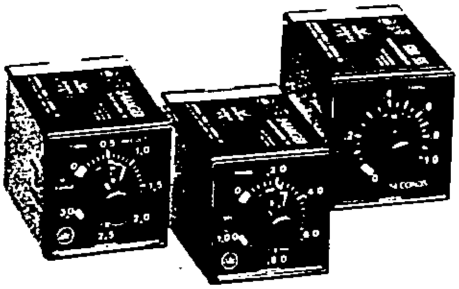
Clifford & Snell Limited
512 Purley Way, Croydon, Surrey CR0 4NZ, England
Tel: 01-681 3331 Telex: 946507 Fax: 01-681 2293

CSNS28/1E/587/GA

AN ECONOMICAL SOLID-STATE TDR
WITH OCTAL PLUG-IN BASE.
THE ATC 319 MAINTAINS EXCELLENT
REPEAT ACCURACY DESPITE WIDE VOLTAGE
AND TEMPERATURE VARIATIONS,
EVEN AFTER LONG PERIODS OF DOWN-TIME.
ONE MODEL HAS FIVE DIAL-SELECTED
ADJUSTABLE RANGES AND PROVIDES
ANY TIMING PERIOD BETWEEN
0.02 SEC AND 30 MIN;
LOWER-COST MODELS INCORPORATE
THREE DIAL-SELECTED RANGES OR
A SINGLE ADJUSTABLE RANGE.

SERIES atc 319 TDR SS

PLUG-IN ADJUSTABLE AC/DC TDR



PRODUCT HIGHLIGHTS

WIDE CHOICE OF RANGES

In addition to the short ranges expected of an electronic TDR, the 319 is also available with ranges as long as 100 minutes, for AC or DC operation.

An unusually versatile model, the 319D five ranger has five dial-selected ranges — from 0.3 sec to 30 min — and provides any dial-adjustable timing period between 0.02 seconds and 30 minutes; a lower priced option (model 319D three ranger) has three dial-selected ranges in two models (1, 10 and 100 sec and 1, 10, and 100 min). A single 319D model thus accommodates the needs of a wide range of applications, allowing the user to select — easily and precisely — an appropriate range to permit optimum setting accuracy. The dial face automatically displays the selected range.

The 319B offers a choice of five dial-adjustable fixed ranges between 1 sec and 30 sec.

CYCLE PROGRESS INDICATION

Model 319D.
All options incorporate a light-emitting diode (LED) which is **on** during the time cycle, **off** at the end of timing. The 5-range option also includes a second LED which separately indicates the status of the output relay: **on** when energized, **off** when de-energized.

Model 319B.
A pilot light clearly indicates the control action: it is **on** during the time cycle, **off** at the end of timing.

APPROVALS

FM, CSA
Recognized under the component program of UL.

HIGH ACCURACY

The 319's timing circuit is not subject to the large *plus* error that plagues many electronic TDRs after long periods of down-time: it maintains rated accuracy regardless of reset time variations, provided that there is at least 0.1 sec between cycles for Model 319D; or at least 10 sec between cycles for Model 319B. All models hold unusually high repeat accuracy in the face of wide voltage and temperature swings.

OPERATION

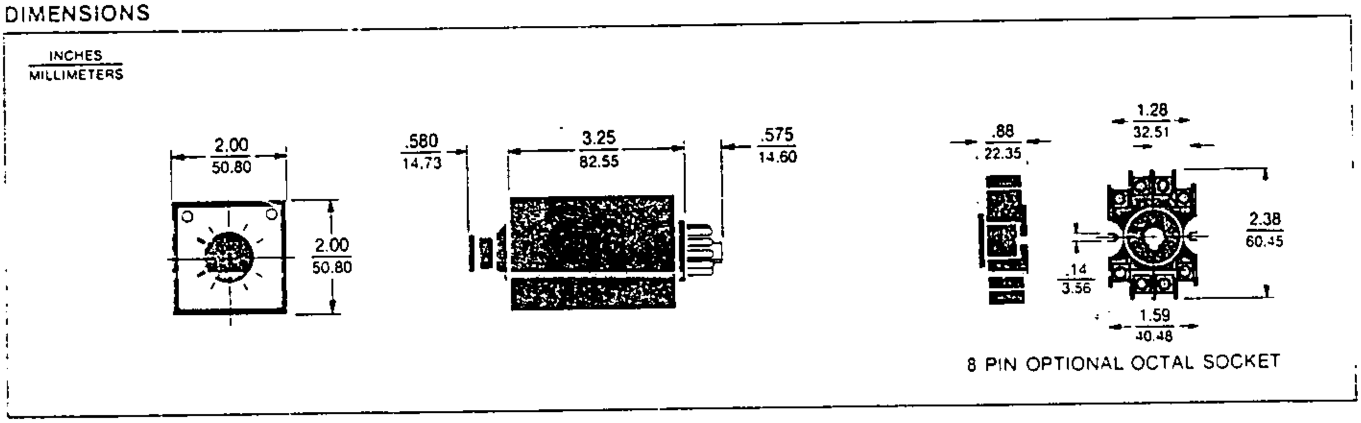
Model 319D
Timing begins when the *start* switch is closed. At the same time, the *Timing* LED goes **on** and a relaxation oscillator starts to run at a rate determined by the dial adjustment. The 319D times out — and the *Timing* LED turns **off** — when the oscillator count is equal to the level set by the range switch.

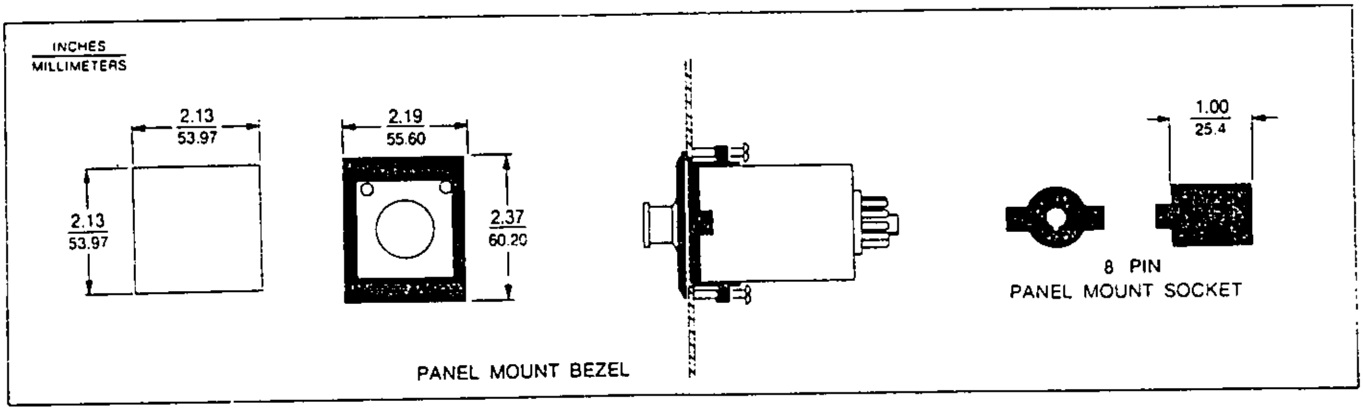
At time-out, the load relay is energized, transferring its contacts, and the timing circuit is automatically de-energized. Reset occurs when the *start* switch is opened or when power is interrupted.

With Model 319D-016, a second LED (labeled *Timed Out*) turns **on** when the load relay is energized at time-out; and **off** when the start switch is opened or power is interrupted.

Model 319B
Timing begins when the *start* switch is closed, and a capacitor immediately begins to accumulate a charge through a fixed resistor. The 319B times out when the capacitor reaches a voltage level which is determined by the position of the dial adjustment. At time-out, the relay is energized, transferring its contacts, and the timing circuit is automatically de-energized. Reset occurs when the *start* switch is opened, or power is interrupted.

DIMENSIONS





SPECIFICATIONS

For All Models

MODELS
Choice of two.
(319D — AC or DC: 3 or 5 dial-selected adj. ranges)
(319B — AC: single adj. range)
All models operate in **on-delay** mode only

LOAD RELAY
TYPE: DPDT (2 Form C)
LIFE: AC: 50,000,000 operations (no load)
DC: 100,000,000 operations (no load)
CONTACT RATING:
AC: 7A resistive at 120 or 240V
DC: 3A at 30V

TEMPERATURE RATING
0° to 70°C (32° to 158°F)

WEIGHT
NET: 6 oz
SHIPPING: 10 oz

MOUNTING
Plug-in octal base: mounts in any position.
OPTIONAL: surface-mounting socket; panel-mounting bezel kit and plug-on socket kit for Model 319D.

HOUSING
Dust, moisture and impact-resistant molded plastic case.

SETTING ACCURACY
10% at full scale

For Model 319D

RANGES AND MINIMUM SETTING
Model 319D-016:
five dial-selected ranges:
0.02 sec — 0.3 sec
0.07 sec — 3.0 sec
0.6 sec — 30.0 sec
3.5 sec — 3.0 min
35.0 sec — 30.0 min
Model 319D-134:
three dial-selected ranges:
0.04 — 1.0 sec
0.2 — 10.0 sec
2.0 — 100.0 sec
Model 319D-300:
three dial-selected ranges:
0-1 min — 2.5 sec.
0-10 min — 23.0 sec.
0-100 min — 3.0 min.

REPEAT ACCURACY
Varies as a function of line voltage and temperature but not of reset time (see Recycle Characteristics):
± 1% of range or 2.0 ms (whichever is greater), when temperature is constant and line voltage is constant or varies within limits*
± 4% of range or 2.0 ms (whichever is greater), when line voltage is constant and temperature varies within limits*
± 6% of range or 2.0 ms (whichever is greater), when line voltage and temperature vary within limits*
*Variations of line voltage must be within 95 and 132V; of temperature between 0° and 70°C (32° and 158°F)

RECYCLE CHARACTERISTICS
When 0.1 sec or longer of reset time is allowed after time-out or after power interruption, the next cycle is timed at full repeat accuracy; when only 0.07 sec is allowed, the next cycle is shortened by as much as 1%.

RESET
5 ms if power is interrupted any time *after* time-out; 70 ms if power is interrupted *during* timing.

POWER REQUIREMENTS
120V AC: 95 to 132V, 50/60 Hz, 0.011A
240V AC: 190 to 264V, 50/60 Hz, 0.011A
24V AC: 21 to 28V, 50/60 Hz, 0.05A
24V DC: 21 to 28V, 0.05A, 50% ripple max.

For Model 319B

RANGES AND MINIMUM SETTING
Choice of five ranges:
0.15 — 1 sec
0.2 — 3 sec
0.2 — 6 sec
0.3 — 10 sec
0.5 — 30 sec

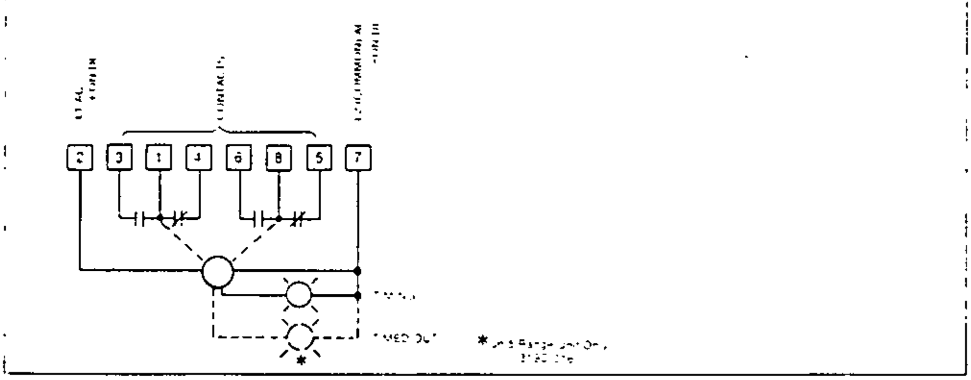
REPEAT ACCURACY
Varies as a function of line voltage, temperature and reset time*:
± 1% of setting or 15ms, when all three conditions are constant.
± 4% of setting or ± 1% of range, when one condition varies.
± 6% of setting or ± 3% of range, when two operating conditions vary.
± 8% of setting or ± 3% of range, when all three conditions vary.
*Variations of line voltage must be within 102 and 132V; of temperature between 75° and 150°F; of reset time between 10 sec and 10 min.

RECYCLE CHARACTERISTICS
When 10 seconds or more of reset time is allowed after time-out or after power interruption, the next cycle is timed at full repeat accuracy; when only 5 seconds is allowed, the next cycle is shortened by as much as 1.5%; when only 0.5 sec, by as much as 5.0%.

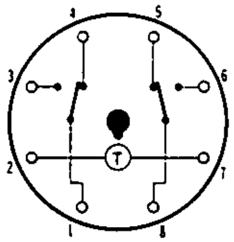
RESET
20 ms if power is interrupted at least 0.1 sec *after* timeout; 100 ms if power is interrupted *during* timing.

POWER REQUIREMENTS:
120V AC: 95 to 132V, 50/60 Hz, 0.01A
240V AC: 190 to 264V, 50/60 Hz, 0.005A

WIRING



TERMINAL WIRING

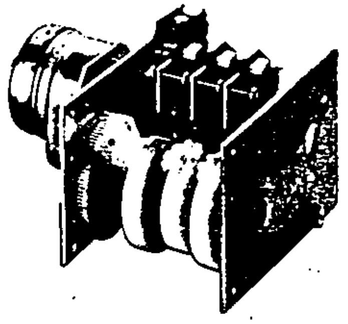


SERIES

324 CAMTIME

PRECISION SWITCH CAM PROGRAMMER

A COMPACT AND ECONOMICAL MOTOR-DRIVEN CAM TIMER. THE 324C PRECISELY CONTROLS ONE TO TWELVE LOAD CIRCUITS THROUGH EASILY-SET SCREWDRIVER-ADJUSTABLE CAMS. EACH TIMER PROVIDES A WIDE RANGE OF CYCLE TIMES THROUGH A SET OF INTERCHANGEABLE GEARS. THE 324C CAN ALSO BE USED WITHOUT A MOTOR AS A ROTARY CAM LIMIT SWITCH WITH BIDIRECTIONAL SWITCHES.



PRODUCT HIGHLIGHTS

EASY AND PRECISE CAM ADJUSTMENT

With ATC's unique split-cam design, each side of the cam is separately screwdriver-adjustable in either direction: either side determines the precise instant during the cycle when the switch will actuate, the other side determines how long the switch will remain actuated. Adjustments are easy and precise: 1/4 turn of the adjusting screw equals 1/2% of cycle time. A setting disc, calibrated in 1% increments, facilitates program set-up and indicates cycle progress.

APPROVALS

UL, CSA

ONE TO TWELVE PRECISION SWITCHES

Whether used as a time or sequence programmer, the 324C can be ordered with any number of cam-operated switches from one to twelve. Each SPDT precision switch is rated at 10 amps, 120V AC and is 1/3 hp rated at 120 or 240V AC.

WIDE RANGE OF CYCLE TIMES

The 324C is available with a choice of 14 synchronous motors that provide more than 270 cycle times between 3 sec and 60 hrs. Each motor provides an adjustable range of 21 cycle times, with a ratio of over 2.5:1, through a set of interchangeable gears. Changing gears is a simple operation that takes only a few minutes.

TOP ACCURACY

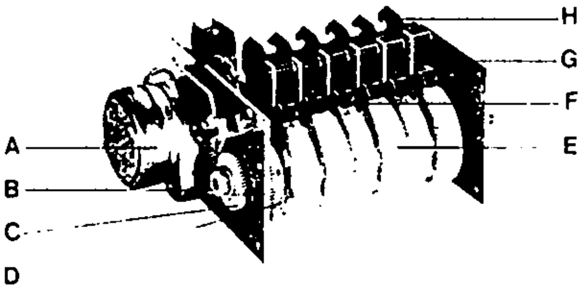
The repeat accuracy and setting accuracy of the 324C are both within ± 1/4%, tops in its field. Follower fingers precisely track the contour of the cams, accurately operating the precision switches with quick-make and quick-break action.

SEQUENCE CONTROL

The 324C can be ordered without a motor and with a 1-inch long shaft extension on either or both ends, for use as a rotary cam limit switch. The unit is then fitted with bidirectional switches.

OPERATION

The 324C comprises eight basic functional assemblies which operate as follows: the synchronous motor (A) drives a hex shaft (B) through a series of interchangeable gears (C) which rotate the setting disc (D) and the cam assemblies (E). Follower fingers (F) track the contour of the split cams, actuating the precision switches (G) at the precise point where the cam face is cut. Loads are connected directly to the switches through their easily accessible terminals (H) that accept standard push-on connectors.



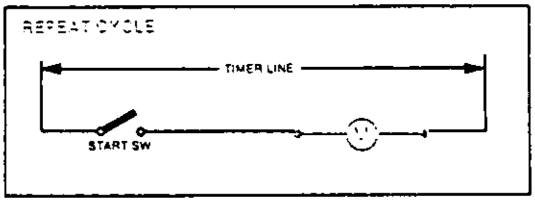
BASIC APPLICATIONS

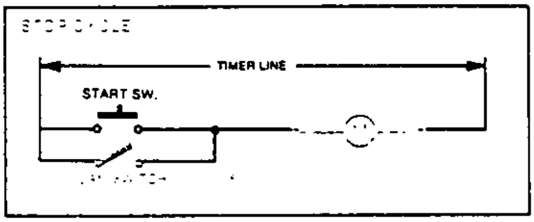
REPEAT CYCLE.
The timer runs continuously, repeating cycles as long as power is applied to the motor through an external *start* switch. The timer stops when power is cut off, and resumes the interrupted cycle when power is restored.

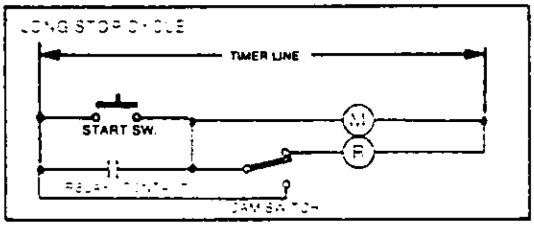
STOP CYCLE.
Power is applied to the motor through a *start* switch which the user wires in parallel with one of the timer's cam-operated *stop* contacts and in series with the motor. Whenever the *start* switch is closed for at least 1% of cycle, the *stop* contact maintains the motor circuit for one full cycle; the timer then stops.

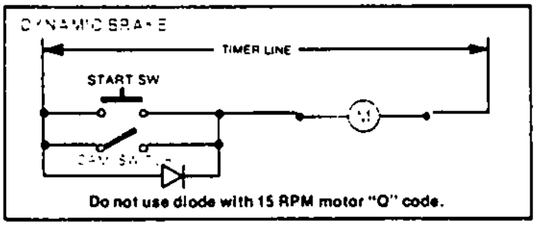
LONG STOP CYCLE.
Used when the timer must operate from a momentary *start* signal that is less than 1% of cycle time, this circuit includes a factory-supplied and wired holding relay. The relay maintains the motor circuit for 1% of cycle until the cam switch transfers. The cam switch maintains the motor ciruit for the balance of the cam rotation, ending the cycle when the cam switch opens.

DYNAMIC BRAKE.
This circuit prevents coasting, stopping the timer instantly when power is removed from the motor. The brake consists of a diode assembly (Part No. 230026056) which the user wires in parallel with one of the timer's cam operated *stop* contacts. It is required in all stop cycle timers with a cycle time of 120 seconds or less, except those that use the 15 RPM permanent magnet motor Q which needs no brake.









Do not use diode with 15 RPM motor "Q" code.

SPEED CHARTS

		15 RPM MOTOR P						15 RPM MOTOR- Q* High Torque—Permanent Magnet Type						5 RPM MOTOR A					
	CAM SHAFT GEAR	MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE	MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE	MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE
SECONDS resulting speed at 60 cycles	30	3	P3A	4	P2A	5	P1A	3	Q3A	4	Q2A	5	Q1A	9	A3A	12	A2A	15	A1A
	36	3.6	P3B	4.8	P2B	6	P1B	3.6	Q3B	4.8	Q2B	6	Q1B	10.8	A3B	14.4	A2B	18	A1B
	40	4	P3C	5.33	P2C	6.66	P1C	4	Q3C	5.33	Q2C	6.66	Q1C	12	A3C	16	A2C	20	A1C
	45	4.5	P3D	6	P2D	7.5	P1D	4.5	Q3D	6	Q2D	7.5	Q1D	13.5	A3D	18	A2D	22.5	A1D
	50	5	P3E	6.66	P2E	8.33	P1E	5	Q3E	6.66	Q2E	8.33	Q1E	15	A3E	20	A2E	25	A1E
	55	5.5	P3F	7.33	P2F	9.16	P1F	5.5	Q3F	7.33	Q2F	9.16	Q1F	16.5	A3F	22	A2F	27.5	A1F
	60	6	P3G	8	P2G	10	P1G	6	Q3G	8	Q2G	10	Q1G	18	A3G	24	A2G	30	A1G
SECONDS resulting speed at 50 cycles	30	3.6	P3A	4.8	P2A	6	P1A	3.6	Q3A	4.8	Q2A	6	Q1A	10.8	A3A	14.4	A2A	18	A1A
	36	4.3	P3B	5.76	P2B	7.2	P1B	4.3	Q3B	5.76	Q2B	7.2	Q1B	12.96	A3B	17.28	A2B	21.6	A1B
	40	4.8	P3C	6.4	P2C	8	P1C	4.8	Q3C	6.4	Q2C	8	Q1C	14.4	A3C	19.2	A2C	24	A1C
	45	5.4	P3D	7.2	P2D	9	P1D	5.4	Q3D	7.2	Q2D	9	Q1D	16.2	A3D	21.6	A2D	27	A1D
	50	6	P3E	8	P2E	10	P1E	6	Q3E	8	Q2E	10	Q1E	18	A3E	24	A2E	30	A1E
	55	6.6	P3F	8.8	P2F	11	P1F	6.6	Q3F	8.8	Q2F	11	Q1F	19.8	A3F	26.4	A2F	33	A1F
	60	7.2	P3G	9.6	P2G	12	P1G	7.2	Q3G	9.6	Q2G	12	Q1G	21.6	A3G	28.8	A2G	36	A1G

		5 RPH MOTOR F						2.5 RPH MOTOR G					
	CAM SHAFT GEAR	MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE	MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE
MINUTES resulting speed at 60 cycles	30	9	F3A	12	F2A	15	F1A	18	G3A	24	G2A	30	G1A
	36	10.8	F3B	14.4	F2B	18	F1B	21.6	G3B	28.8	G2B	36	G1B
	40	12	F3C	16	F2C	20	F1C	24	G3C	32	G2C	40	G1C
	45	13.5	F3D	18	F2D	22.5	F1D	27	G3D	36	G2D	45	G1D
	50	15	F3E	20	F2E	25	F1E	30	G3E	40	G2E	50	G1E
	55	16.5	F3F	22	F2F	27.5	F1F	33	G3F	44	G2F	55	G1F
	60	18	F3G	24	F2G	30	F1G	36	G3G	48	G2G	60	G1G
MINUTES resulting speed at 50 cycles	30	10.8	F3A	14.4	F2A	18	F1A	21.6	G3A	28.8	G2A	36	G1A
	36	12.96	F3B	17.28	F2B	21.6	F1B	25.92	G3B	34.56	G2B	43.2	G1B
	40	14.4	F3C	19.2	F2C	24	F1C	28.8	G3C	38.4	G2C	48	G1C
	45	16.2	F3D	21.6	F2D	27	F1D	32.4	G3D	43.2	G2D	54	G1D
	50	18	F3E	24	F2E	30	F1E	36	G3E	48	G2E	60	G1E
	55	19.8	F3F	26.4	F2F	33	F1F	39.6	G3F	52.8	G2F	66	G1F
	60	21.6	F3G	28.8	F2G	36	F1G	43.2	G3G	57.6	G2G	72	G1G

		⅙ RPH MOTOR L						1/12 RPH MOTOR M						1/24 RPH MOTOR N					
	CAM SHAFT GEAR	MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE	MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE	MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE
HOURS resulting speed at 60 cycles	30	4.5	L3A	6	L2A	7.5	L1A	9	M3A	12	M2A	15	M1A	18	N3A	24	N2A	30	N1A
	36	5.4	L3B	7.2	L2B	9	L1B	10.8	M3B	14.4	M2B	18	M1B	21.6	N3B	28.8	N2B	36	N1B
	40	6	L3C	8	L2C	10	L1C	12	M3C	16	M2C	20	M1C	24	N3C	32	N2C	40	N1C
	45	6.75	L3D	9	L2D	11.25	L1D	13.5	M3D	18	M2D	22.5	M1D	27	N3D	36	N2D	45	N1D
	50	7.5	L3E	10	L2E	12.5	L1E	15	M3E	20	M2E	25	M1E	30	N3E	40	N2E	50	N1E
	55	8.25	L3F	11	L2F	13.75	L1F	16.5	M3F	22	M2F	27.5	M1F	33	N3F	44	N2F	55	N1F
	60	9	L3G	12	L2G	15	L1G	18	M3G	24	M2G	30	M1G	36	N3G	48	N2G	60	N1G
HOURS resulting speed at 50 cycles	30	5.4	L3A	7.2	L2A	9	L1A	10.8	M3A	14.4	M2A	18	M1A	21.6	N3A	28.8	N2A	36	N1A
	36	6.48	L3B	8.64	L2B	10.8	L1B	12.96	M3B	17.28	M2B	21.6	M1B	25.92	N3B	34.56	N2B	43.2	N1B
	40	7.2	L3C	9.6	L2C	12	L1C	14.4	M3C	19.2	M2C	24	M1C	28.8	N3C	38.4	N2C	48	N1C
	45	8.1	L3D	10.8	L2D	13.5	L1D	16.2	M3D	21.6	M2D	27	M1D	32.4	N3D	43.2	N2D	54	N1D
	50	9	L3E	12	L2E	15	L1E	18	M3E	24	M2E	30	M1E	36	N3E	48	N2E	60	N1E
	55	9.9	L3F	13.2	L2F	16.5	L1F	19.8	M3F	26.4	M2F	33	M1F	39.6	N3F	52.8	N2F	66	N1F
	60	10.8	L3G	14.4	L2G	18	L1G	21.6	M3G	28.8	M2G	36	M1G	43.2	N3G	57.6	N2G	72	N1G

TIME CYCLE ORDERING CODES

Select Time Cycle from table below, if it is available with more than one motor and gearing combination, pick the combination which would best accommodate potential future speed changes. 3 Digit Speed Code identifies motor — gearing as follows

ORDERING CODE [illegible] (Example)

MOTOR SPEED

A	5 rpm	**H**	1 rph
B	150 rph	**J**	½ rph
C	1 rpm	**L**	1/6 rph
D	½ rpm	**M**	1/12 rph
E	15 rph	**N**	1/24 rph
F	5 rph	**P**	15 rpm
G	2.5 rph	**Q**	15 rpm
		K	Special

MOTOR PINION

1	24 Teeth	23004950100
2	30 Teeth	23004950200
3	40 Teeth	23004950300

CAM SHAFT GEAR

		Part No.
A	30 Teeth	23004951100
B	36 Teeth	23004951200
C	40 Teeth	23004951300
D	45 Teeth	23004951400
E	50 Teeth	23004951700
F	55 Teeth	23004951500
G	60 Teeth	23004951600

150 RPH MOTOR B **1 RPM MOTOR C** **½ RPM MOTOR D** **15 RPH MOTOR E**

MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE	MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE	MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE	MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE
13	B3A	24	B2A	30	B1A	45	C3A	60	C2A	75	C1A	90	D3A	120	D2A	150	D1A	180	E3A	240	E2A	300	E1A
21.6	B3B	28.8	B2B	36	B1B	54	C3B	72	C2B	90	C1B	108	D3B	144	D2B	180	D1B	215	E3B	288	E2B	360	E1B
24	B3C	32	B2C	40	B1C	60	C3C	80	C2C	100	C1C	120	D3C	160	D2C	200	D1C	240	E3C	320	E2C	400	E1C
27	B3D	36	B2D	45	B1D	67.5	C3D	90	C2D	112.5	C1D	135	D3D	180	D2D	225	D1D	270	E3D	360	E2D	450	E1D
30	B3E	40	B2E	50	B1E	75	C3E	100	C2E	125	C1E	150	D3E	200	D2E	250	D1E	300	E3E	400	E2E	500	E1E
33	B3F	44	B2F	55	B1F	82.5	C3F	110	C2F	137.5	C1F	165	D3F	220	D2F	275	D1F	330	E3F	440	E2F	550	E1F
36	B3G	48	B2G	60	B1G	90	C3G	120	C2G	150	C1G	180	D3G	240	D2G	300	D1G	360	E3G	480	E2G	600	E1G
21.6	B3A	28.8	B2A	36	B1A	54	C3A	72	C2A	90	C1A	108	D3A	144	D2A	180	D1A	216	E3A	288	E2A	360	E1A
25.92	B3B	34.56	B2B	43.2	B1B	64.8	C3B	86.4	C2B	108	C1B	129.6	D3B	172.8	D2B	215	D1B	259.2	E3B	345.6	E2B	432	E1B
28.8	B3C	38.4	B2C	48	B1C	72	C3C	96	C2C	120	C1C	144	D3C	192	D2C	240	D1C	288	E3C	384	E2C	480	E1C
32.4	B3D	43.2	B2D	54	B1D	81	C3D	108	C2D	135	C1D	162	D3D	215	D2D	270	D1D	324	E3D	432	E2D	540	E1D
36	B3E	48	B2E	60	B1E	90	C3E	120	C2E	150	C1E	180	D3E	240	D2E	300	D1E	360	E3E	480	E2E	600	E1E
39.6	B3F	52.8	B2F	66	B1F	99	C3F	132	C2F	165	C1F	198	D3F	264	D2F	330	D1F	395	E3F	528	E2F	660	E1F
43.2	B3G	57.6	B2G	72	B1G	108	C3G	144	C2G	180	C1G	215	D3G	288	D2G	360	D1G	432	E3G	576	E2G	720	E1G

1 RPH MOTOR H **½ RPH MOTOR J**

MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE	MOTOR PINION 3 40 TOOTH	CODE	MOTOR PINION 2 30 TOOTH	CODE	MOTOR PINION 1 24 TOOTH	CODE
45	H3A	60	H2A	75	H1A	90	J3A	120	J2A	150	J1A
54	H3B	72	H2B	90	H1B	108	J3B	144	J2B	180	J1B
60	H3C	80	H2C	100	H1C	120	J3C	160	J2C	200	J1C
67.5	H3D	90	H2D	112.5	H1D	135	J3D	180	J2D	225	J1D
75	H3E	100	H2E	125	H1E	150	J3E	200	J2E	250	J1E
82.5	H3F	110	H2F	137.5	H1F	165	J3F	220	J2F	275	J1F
90	H3G	120	H2G	150	H1G	180	J3G	240	J2G	300	J1G
54	H3A	72	H2A	90	H1A	108	J3A	144	J2A	180	J1A
64.8	H3B	86.4	H2B	108	H1B	129.6	J3B	172.8	J2B	216	J1B
72	H3C	96	H2C	120	H1C	144	J3C	192	J2C	240	J1C
81	H3D	108	H2D	135	H1D	162	J3D	216	J2D	270	J1D
90	H3E	120	H2E	150	H1E	180	J3E	240	J2E	300	J1E
99	H3F	132	H2F	165	H1F	198	J3F	264	J2F	330	J1F
108	H3G	144	H2G	180	H1G	215	J3G	288	J2G	360	J1G

[illegible]

The ability of the 324C to trip a number of load contacts simultaneously is determined in the chart below. Pick the vertical column that corresponds to the total number of contacts you need and proceed down the column to a point where it intersects the horizontal column that corresponds to the fastest time cycle you intend to use. If the intersection of the two columns is in the gray, there is no limitation to the 324's ability to trip contacts simultaneously: if not, the limit is noted in the intersected square.

TIME CYCLE (Seconds)		MAXIMUM NUMBER OF CONTACTS SWITCHING TOGETHER											
		Total Number of Contacts											
Two Motors	One Motor	1	2	3	4	5	6	7	8	9	10	11	12
—	5		1	1	—	—	—	—	—	—	—	—	—
3	6			1	1	1	—	—	—	—	—	—	—
3½	7			2	2	1	1	—	—	—	—	—	—
4	8			2	2	2	1	1	—	—	—	—	—
4½	9				3	2	2	1	1	—	—	—	—
5	10				3	3	2	2	1	1	—	—	—
7½	15						5	4	4	3	3	3	2
10	20								7	6	6	5	5
12½	25									8	7	7	7
15	30				NO LIMIT								10
17½	35												
20	40												
all slower cycles													

*THIS TABLE APPLIES TO Q MOTOR *ONLY*

Time cycle seconds one motor	MAXIMUM NUMBER OF CONTACTS SWITCHING TOGETHER											
	Total Number of Contacts											
	1	2	3	4	5	6	7	8	9	10	11	12
3.0								6	5	4	3	2
3.6									8	7	6	5
4.0										9	8	7
4.5				NO LIMIT								10
4.8												11
5.0												
All slower cycles listed for this motor												

15 RPM Motor—Q—High torque permanent magnet, no brake diode required on stop cycle units.

SPECIFICATIONS

CYCLE TIMES
More than 270 cycle times from 3 sec to 60 hrs. from a choice of interchangeable motors and gears; each motor provides more than 20 cycle times. (see Speed Charts).

REPEAT ACCURACY
± ¼ % of cycle time.

SETTING ACCURACY
± ¼ % of cycle time.

FRAME SIZES
3, 6, 9 and 12 cam frame sizes are provided.

CAMS
NUMBER: 1 to 12 (or multiples up to 12, by combining timer assemblies); cams may be factory-set.
CUT: Standard or "50%" cut", as specified (standard cams allow contact closure adjustment of 1 to 45% or 55 to 99%. "50% cut" cams allow contact closure adjustment of 12 to 52% or 48 to 88%; custom cams available with 2, 3, 4 or more cuts.

CONSTRUCTION: Two-inch diameter; split type; made of Delrin.

LIFE EXPECTANCY
MECHANICAL: over 10,000,000 operations.
CONTACTS: over 1,000,000 operations at less than 1 amp.

LOAD SWITCHES
TYPE: Precision switches; one for each cam.
CONTACT ACTION: SPDT (Form C).
CONTACT RATING: 10 A at 120 V AC (non-inductive). 1/3 HP at 125/250 V AC.
MINIMUM CONTACT ACTUATION TIME: 1% of cycle time

DRIVE MOTORS
SPEED: choice of 14 (see Time Cycle Ordering Codes).
TYPE: Synchronous; permanently lubricated; integral slip clutch for manual advance; anti-backup to prevent damage to switches.
VOLTAGE: 120V AC, 50 or 60 cycles; optional: 24 or 240 V AC, 50 or 60 cycles.
POWER CONSUMPTION: 12 watts max.
DUAL DRIVE: two motors may be used, for dual-speed and special applications.

TORQUE-SPEED CAPABILITIES: At cycle times of 30 sec or longer, the 324 can drive and switch 12 contacts simultaneously; below 30 sec, the motor may be limited in its ability to drive or switch a number of contacts simultaneously. (See speed chart tables).

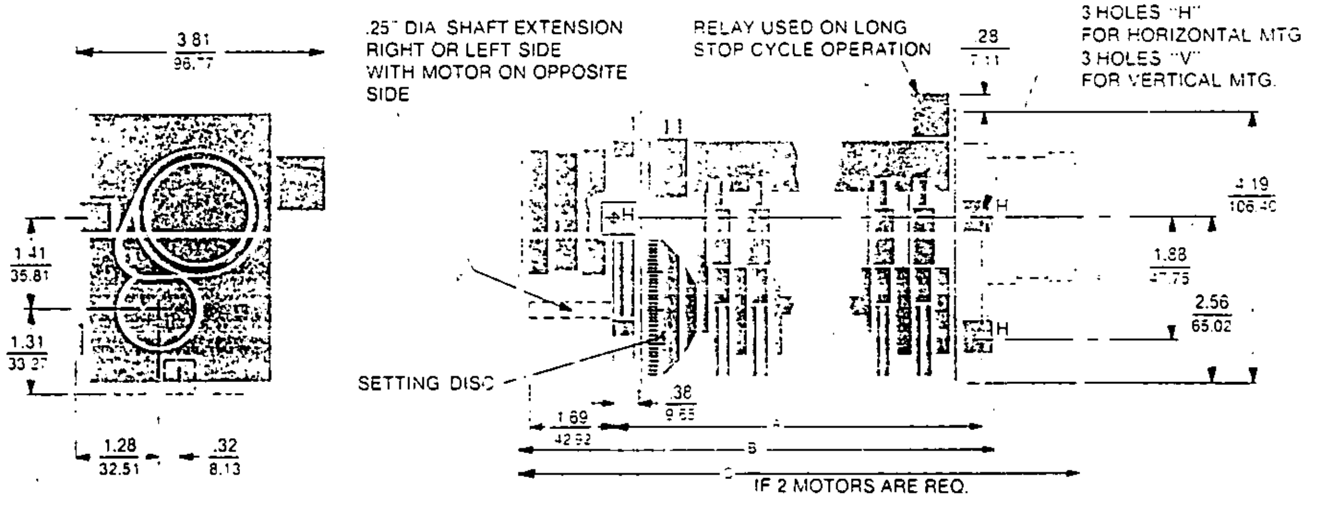
TEMPERATURE RATING
32 to 140°F. (0 to 60°C.)

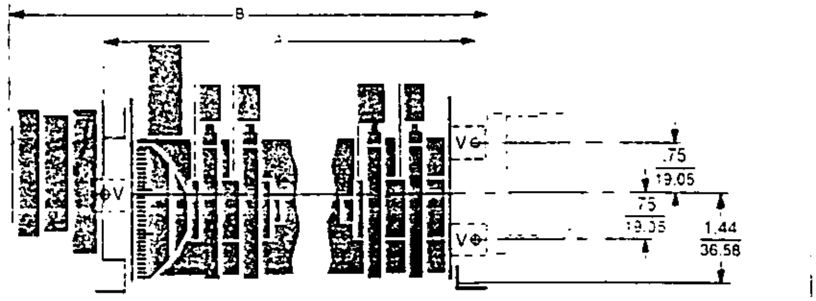
WEIGHT
NET: from 1 ½ lbs. for the 3 cam unit up to 3 ½ lbs. for the 12 cam unit
SHIPPING: from two lbs. for the 3 cam unit up to 4 lbs. for the 12 cam unit

ENCLOSURES (Optional)
(See last pages of Catalog for detailed description).
NEMA 12 molded case for one model 324 with maximum of 3 cams.

[illegible]

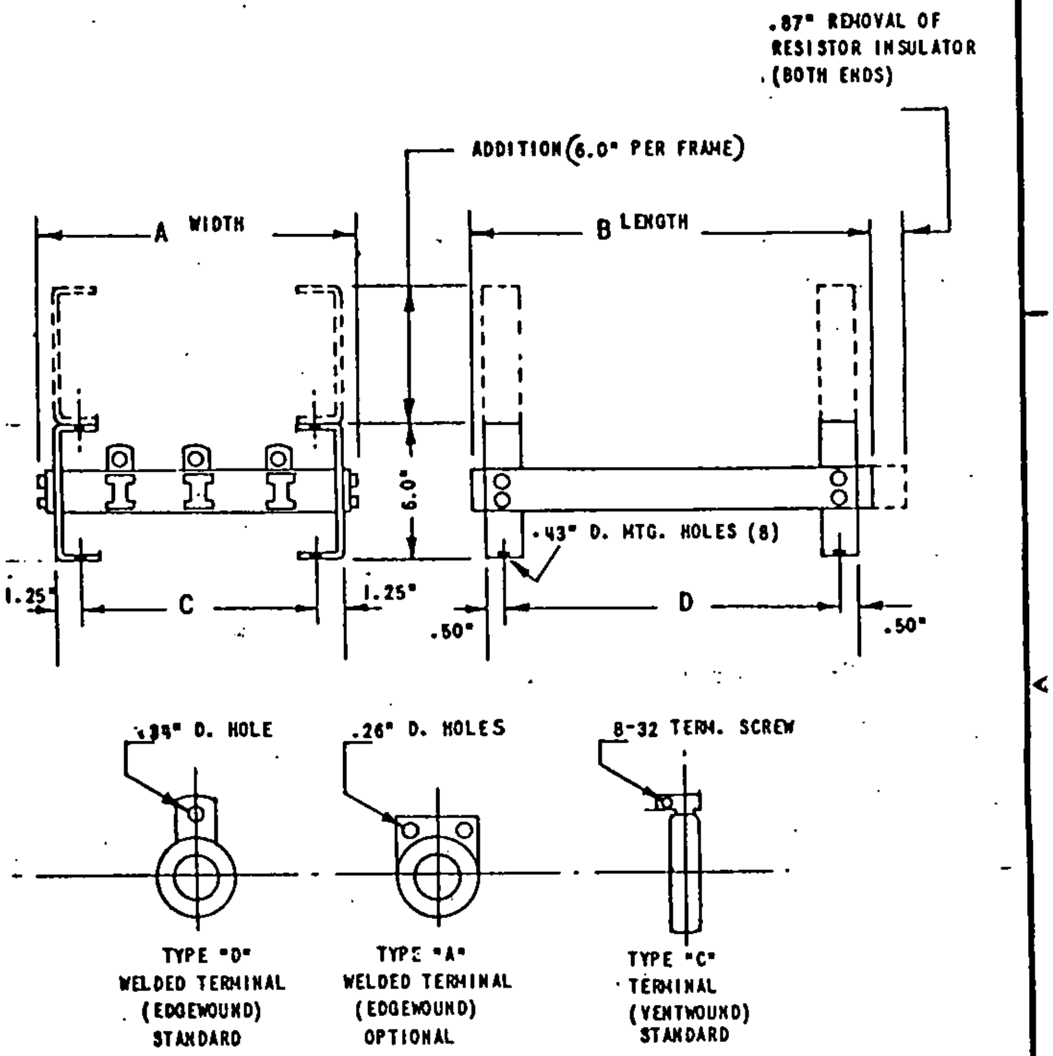
NOTE: THREE MOUNTING FEET, LOCKWASHERS AND SCREWS SUPPLIED WITH EACH TIMER. TIMER CAN BE MOUNTED HORIZONTAL OR VERTICAL. HORIZONTAL MOUNTING SHOWN. VERTICAL MOUNTING SHOWN BY DOTTED LINES.





Number of Cams	Dim A	Dim B	Dim C
3	3.81 / 96.84	5.72 / 145.29	7.22 / 183.39
6	5.69 / 144 5	7.59 / 192.79	9.09 / 230.89
9	7.56 / 192.02	9.47 / 240.54	10.97 / 278.64
12	9.44 / 239 78	11.34 / 288.04	12.84 / 326.14

ITEM	MAX. NO COILS PER FRAME	UNIT LENGTH RESISTOR	A	B	C	D
1	2	3	7.50"	13.18"	4.37"	11.12"
2	3	3	10.25"	13.18"	7.12"	11.12"
3	4	3	13.00"	13.18"	9.87"	11.12"
4	5	3	15.75"	13.18"	12.62"	11.12"
5	6	3	18.50"	13.18"	15.37"	11.12"
6	7	3	21.25"	13.18"	18.12"	11.12"
7	2	4	7.50"	16.12"	4.37"	14.06"
8	3	4	10.25"	16.12"	7.12"	14.06"
9	4	4	13.00"	16.12"	9.87"	14.06"
10	5	4	15.75"	16.12"	12.62"	14.06"
11	6	4	18.50"	16.12"	15.37"	14.06"
12	7	4	21.25"	16.12"	18.12"	14.06"
13	2	5	7.50"	19.06"	4.37"	17:00"
14	3	5	10.25"	19.06"	7.12"	17.00"
15	4	5	13.00"	19.06"	9.87"	17.00"
16	5	5	15.75"	19.06"	12.62"	17.00"
17	6	5	18.50"	19.06"	15.37"	17.00"
18	7	5	21.25"	19.06"	18.12"	17.00"
19	2	6	7.50"	22.00"	4.37"	19.93"
20	3	6	10.25"	22.00"	7.12"	19.93"
21	4	6	13.00"	22.00"	9.87"	19.93"
22	5	6	15.75"	22.00"	12.62"	19.93"
23	6	6	18.50"	22.00"	15.37"	19.93"
24	7	6	21.25"	22.00"	18.12"	19.93"
25	2	7	7.50"	24.93"	4.37"	22.87"
26	3	7	10.25"	24.93"	7.12"	22.87"
27	4	7	13.00"	24.93"	9.87"	22.87"
28	5	7	15.75"	24.93"	12.62"	22.87"
29	6	7	18.50"	24.93"	15.37"	22.87"
30	7	7	2 1.25"	24.93"	18.12"	22.87"



E			
D			
C			
B			
A			
	DATE	BY	DESCRIPTION

LINEAR		HOLES			ANGLES
DECIMAL	1 PLACE ± .050	PUNCH		± .002	DIMEN. ± 1°
	2 PLACE ± .020	DRILL	.5 OR LESS	+ .004 − .002	
	3 PLACE ± .005		OVER .5	+ .010 − .004	UNDIMEN. 90° ± 2°
			REAM - SPECIFIED		

RESISTOR OUTLINE
FOR TYPE SSR (SLOT MTD.)
6" HIGH OPEN TYPE
FRAME ASSEMBLY

R.M.S. | DATE 6-3-76 | DR. EJC | CK. | APPR. | REF.

Industrial Controls Division
HARVEY HUBBELL INCORPORATED
Madison, Ohio 44057

DRG. NO. A-69309
1 OF 2

10-6-83	RK/+R	[illegible]	RK			BULL.

WIRE DIAGRAM	OUTLINES	
	A-69309-27	2 FRAMES

TITLE

LOAD BANK
RESISTOR

HARVEY HUBBELL INCORPORATED
Madison, Ohio 44057

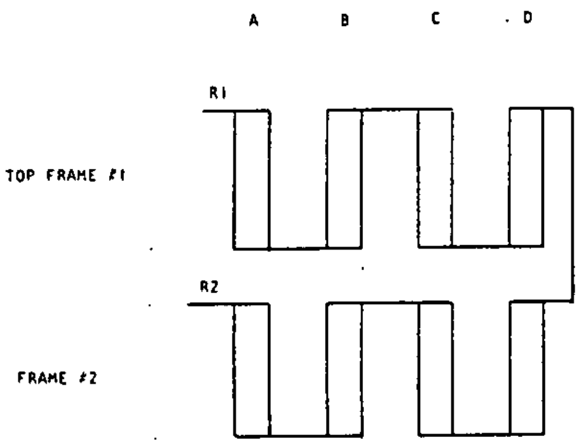
PAGE 1 OF 1

DRIVE ______
CERTIFIED CORRECT ______ DATE ______
H.P. ______ VOLTS ______ PH. ______ HZ. ______
CLASS ______ SEC. VOLTS ______ SEC. AMPS ______
PURCH. ______ P.O. ______
USER ______ S.O. ______

REMARKS-

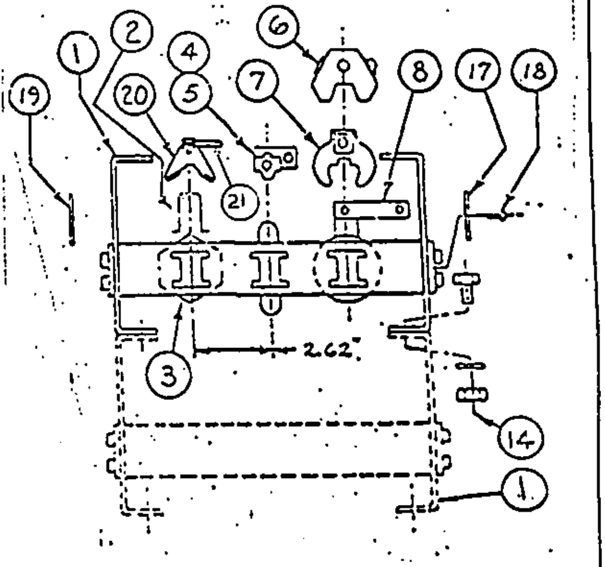
ITEM	ASSEM. OR PART DESCRIPTION	DRG. NO	PART NO.	QTY.
1	FRAME ASSEMBLY OPEN TYPE (4 COIL MAX) 6" HI.		69335-027	2
2	RETAINER CLIP	A-66769	66769-001	16
3	INSULATOR	A-66771	66771-000	16
4	MID TAP TERM. ASSEM. (VENTW.) 6.1 A. MAX.	A-25414	30910-002	
5	MID TAP TERM. ASSEM. (VENTW.) 18.1 A. MAX.	A-25414	30910-001	
6	MID TAP TERM. ASSEM. (EW.) 34A. MAX.	A-25209	17578-001	
7	MID TAP TERM. ASSEM. (EW.) 125 A. MAX.	A-25183	17577-001	
8	COIL JUMPER (2-5/8" CTRS.) (EW)	T-111 -25	9289-000	6
9	# 8 TYPE BARE SOLID WIRE	822-201-99-08		1 FT
10	# TYPE			FT
11	5/16-18 SCREW ASSEM. (CUST. TERM. CONN.) (EW)	B-69262	69262-001	2
12	5/16-18 SCREW ASSEM. (JUMPER TO TERM.) (EW)	D-69262	69262-002	12
13	5/16-18 SCREW ASSEM. (WIRE TO TERM.) (EW).	B-69262	69262-004	2
14	3/8-16 SCREW ASSEM. (END PLATE MTG.)	B-69262	69262-010	4
15				
16				
17	NAME PLATE	B-58441-006	58441-006	1
18	#2 * 1/8" LG. DRIVE SCREW	A-47788	47788-007	2
19	LOGO	B-58441-015	58441-015	1
20	MID TAP TERM. ASSEM. (HEXW.)	A-69430	69430-001	
21	COIL JUMPER (HEXW)	T-111-26	29141-000	

ITEM	COIL REF. NO.	AMPS	OHM	QTY.	PART NO.
1	72701865	27	1.86	8	69287-015
2					
3					
4					
5					
6					
7					
8					
9					
10					



27 AMP COILS

FRONT SIDE



R1-R2	27	15
STEPS	AMPS	OHMS

RESISTOR VALUES

REV.

P/N 69452650

ADDENDUM II

INSTRUCTIONS

Solid-State DC Overcurrent Relay

ITE-76 DC OVERCURRENT RELAY

Catalog Series 206

Sensor Operated

For Transit and Other DC Applications

BBC Brown Boveri, Inc.

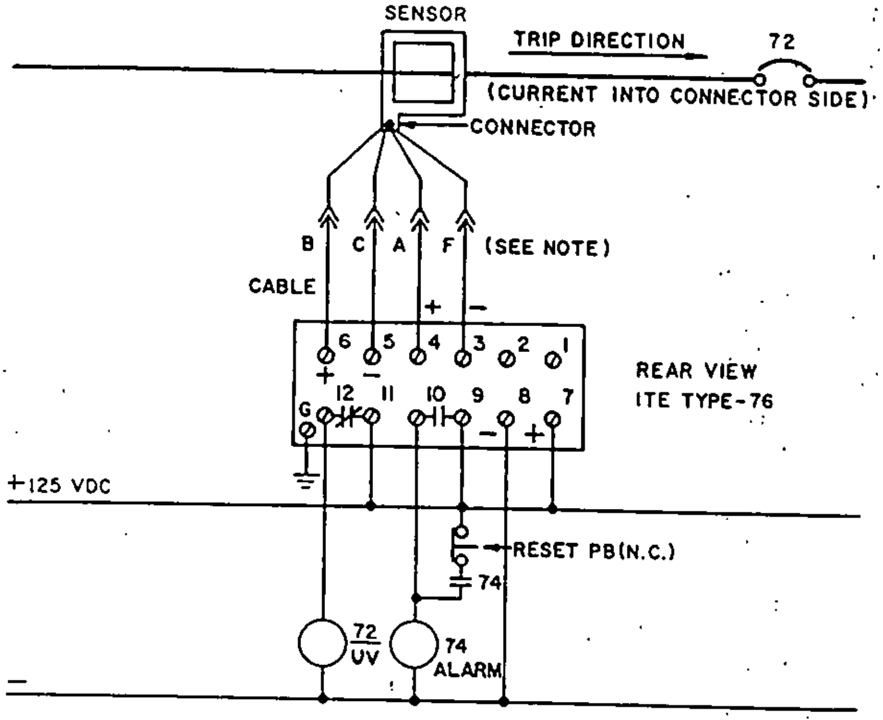
IB 7.5.1.7-1
Addendum II
March 18, 1987

ITE-76 DC Overcurrent Relays with NC Contact Outputs

SCOPE: This Addendum applies to ITE-76 relays, sensor operated, with (1) NC and (1) NO contact.

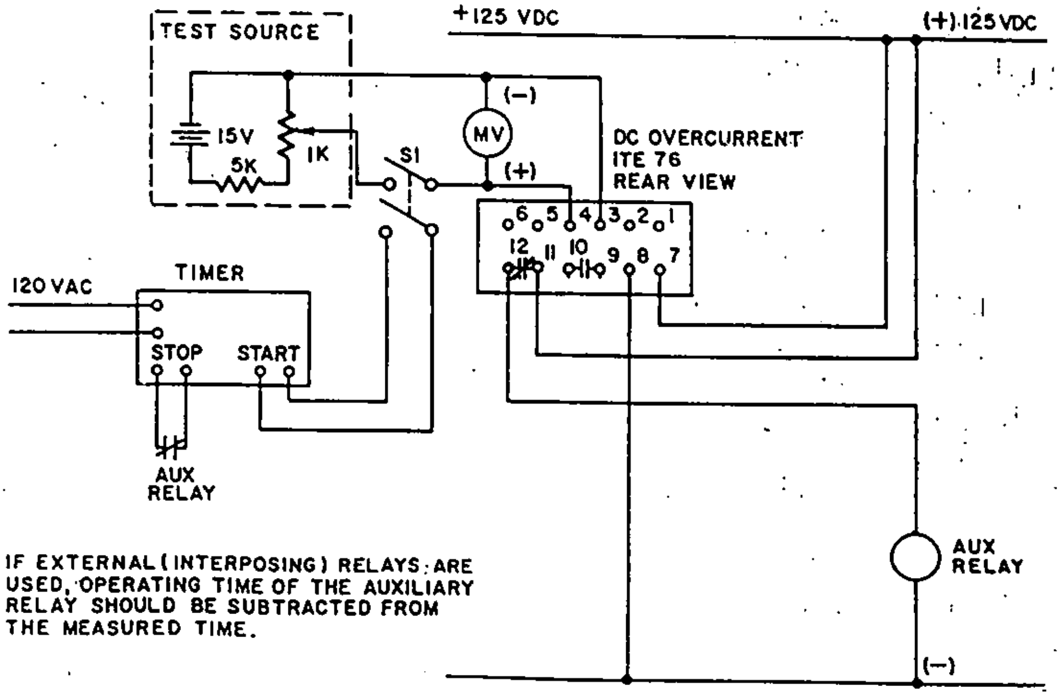
For example: Cat. #206A2280 - Instantaneous only.
Cat. #206D2280 - Rate of Rise only.

SPECIAL INSTRUCTIONS: Refer to applicable information in IB 7.5.1.7-1, except use Figure 2A and Figure 4A on next page for external connections and test circuits.



NOTE: FOR REVERSE TRIP DIRECTION, REVERSE B & C(B TO 5, C TO 6)

FIGURE 2A EXTERNAL CONNECTIONS (TYPICAL)



IF EXTERNAL (INTERPOSING) RELAYS ARE USED, OPERATING TIME OF THE AUXILIARY RELAY SHOULD BE SUBTRACTED FROM THE MEASURED TIME.

FIGURE 4A CALIBRATION TEST SCHEMATIC (Typical)

TABLE OF CONTENTS

INTRODUCTION

These instructions contain the information required to properly install, operate, and test the ITE-76 sensor operated, D.C. Overcurrent Relay.

The relay is housed in a semi-flush drawout relay case suitable for conventional panel mounting.

The connections to the relay are made at terminals located on the rear of the case and clearly numbered, one through twelve.

The controls for setting the relay are located on the front panel behind a removable clear plastic cover. The relays are factory calibrated.

The test button and target indicator are also located on the front panel. The target is reset by means of a pushbutton extending through the relay cover.

A companion sensor is mounted around the dc bus and connects to the relay by means of a special cable.

PRECAUTIONS

The following precautions should be taken when applying these relays:

1. Incorrect wiring may result in damage. Be sure wiring agrees with the connection diagram for the particular relay before the relay is energized. Be sure control power is applied in the correct polarity.

2. Apply only the rated control voltage marked on the relay front panel.

3. Do not attempt to manually operate target vanes on CIRCUIT-SHIELD relays. Although the targets return their indication under shock, they can be damaged by manual operation with a pencil or pointed object.

4. The entire circuit assembly of the relay is removable. This board should insert smoothly. Do not use force.

5. Follow test instructions to verify that the relay is in proper working order.

CAUTION: since troubleshooting entails working with energized equipment, caution should be taken to avoid personal shock. Only competant technicians familiar with good safety practices should service these devices.

6. The Hall-effect sensor must be considered to be at ground potential. Maintain appropriate air clearance to bus bars to provide necessary dielectric strength.

PLACING THE RELAY INTO SERVICE

1. RECEIVING, HANDLING, STORAGE

Upon receipt of the relay (when not included as part of a switchboard) examine for shipping damage. If damage or loss is evident file a claim at once and promptly notify the nearest Brown Boveri Sales Office. Keep the relay clean and dry and use normal care in handling to avoid mechanical damage.

2. INSTALLATION

Mounting

The outline dimensions and panel drilling and cutout information is given in Figure. 1.

Connections

A Typical connection diagram is shown in Figure 2.

The ITE-76 relay has a metal front panel which is connected through printed circuit board runs and connector wiring to a terminal at the rear of the relay case. The terminal is marked "G" and is located as shown in Figure 1. In all applications this terminal should be wired to ground.

The relay requires four leads for connections to a DC current sensor: two for sensor output and two for sensor bias (control) current. Twisted or twisted and shielded pairs are recommended, #22AWG or larger. Normally, a relay-sensor cable (609970 or 609885) terminating in a 7-pin male connector (Positronic GH7MSCLSH19C) is supplied with the relay.

Trip direction of a standard relay is determined by the bus current in the sensor window (magnetic field) and sensor cable connections as shown in Fig. 2.

The positioning of the Hall-effect sensor with respect to the d.c. current carrying bus bar is critical to the calibration of the system and must be determined by test for each equipment configuration. In addition, the sensor must be considered to be at ground potential and appropriate clearances must be maintained to meet the dielective strength requirements of the installation. Contact the factory if additional information is required on these points. Once sensor position and calibration has been properly determined for a given equipment configuration, individual calibration for each frame of gear is not necessary.

3. SETTINGS

The ITE-76 may be provided with any combination of the following three functions depending on the requirements of the application:

Instantaneous Function:

A rotary switch provides four pickup settings for the instantaneous function in multiples of sensor ampere rating: 1,2,3,4x. For example, with a sensor rated 500 amperes and a setting of 4x, the instantaneous function will trip for currents higher than 2000 amperes.

Long Time Function:

A tap block on the upper left of the front panel provides four pickup settings in multiples of sensor ampere rating: 0.5, 0.75, 1.0, 1.25x.

The tap block located on the upper right side of the front panel provides four time delay settings: 5, 10, 15, 20 seconds.

Rate-of-Rise Function:

A potentiometer located on the left side of the front plate provides a setting of the di/dt pickup in multiples of sensor rating in amperes per second: 0.2 to 4x.

A continuously adjustable dial with a range of 0.05 to 0.4 seconds is used to set the required time delay. The rate-of-rise of current must be above pickup for the length of time set on this dial before the relay's output contacts will transfer.

Sensor Control (Bias) Current: (CAL BIAS)

Internally mounted trimmer potentiometer is provided to set sensor bias during calibration (normally 20 mAdc).

Trip Direction:

All trip functions are unidirectional. The ITE-76 relay produces trip output if the input signal is positive at terminal 4 with respect to terminal 3 and is above the trip settings.

Operation Indicators:

Target indicators are provided on the Instantaneous and Rate-of-Rise tripping functions. The targets retain their indication until manually reset. Control power must be present to reset.

CAL NULL Control:

This potentiometer is used to null the offset voltage of internal amplifier U1 during calibration. This adjustment is made at the factory and should not need adjusting in the field.

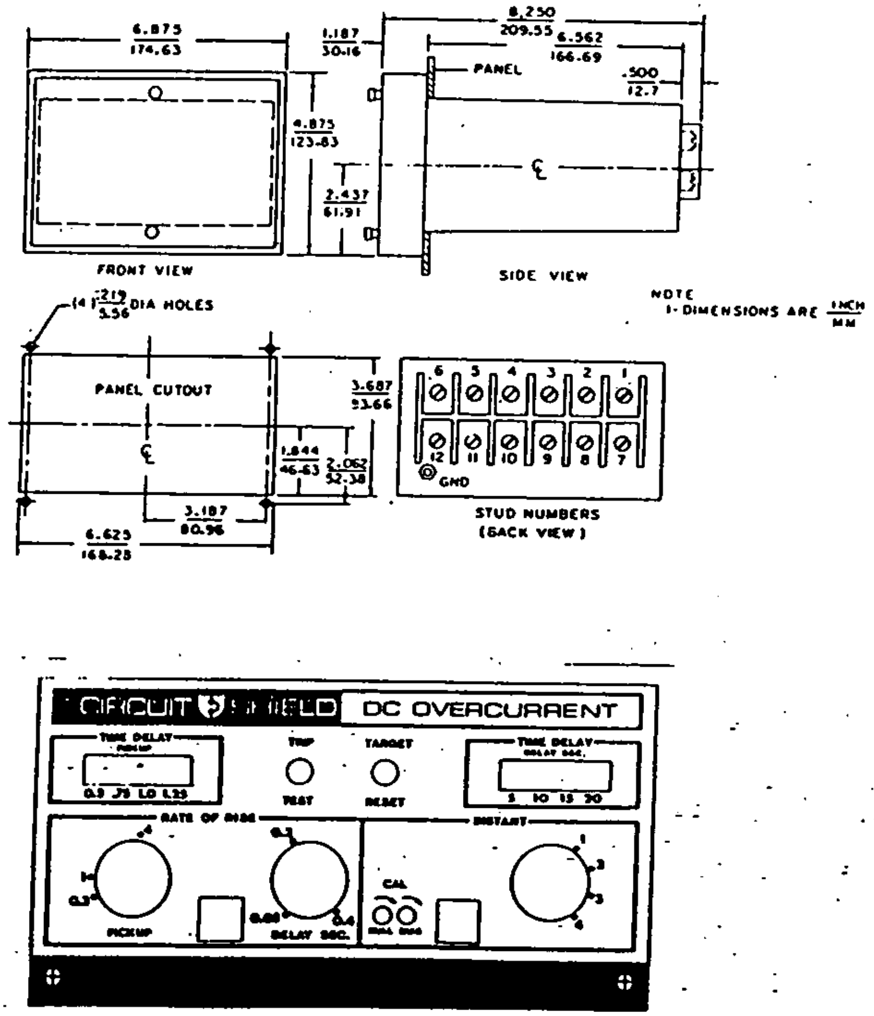


FIGURE 1: Relay Outline, Panel Drilling, and Front Panel Layout

APPLICATION DATA

These relays have been designed especially for use with main and feeder circuit breakers to control the supply of D.C. power to the third-rail, or catenary of transit systems. Several models are available to provide various combinations of protective functions which open the appropriate circuit breaker to isolate the faulty section of the power-distribution system.

The relays are usually mounted on metal-clad switchgear or switchboards, and operate in conjunction with BBC supplied Hall-effect DC current sensors of appropriate current ratings; mounted on BBC Type FBK DC circuit breakers. In standard applications, rated output of sensors is 50mV at a bias (control) current of 20 mAdc supplied by the ITE-76 relay.

System designers who elect to purchase this ITE-76 and companion DC sensors for installation in equipment around or adjacent to DC busses or cables, must check the physical configuration for calibration by comparing sensor output with readings from a separate measuring device such as a main circuit shunt. Sensor positioning can then be adjusted, or a pick-up multiplier could be applied to relay front settings, or the relay recalibrated, as best suits the particular application. Contact the factory for additional information on sensor positioning and calibration of the relay/sensor combination.

Solid-state components measure the output of the sensor, and compare it to the pre-set tripping levels provided by the front accessible, calibrated controls. When an abnormal condition is detected, the Type ITE-76 relay closes its contacts to energize the shunt-trip coil of the circuit breaker.

An example of a typical application is shown in Fig. 3 with reverse current trip in the main circuit and forward trip in the feeder circuits.

Instantaneous Function

Protection against high current short circuit faults is provided by the instantaneous function. The dial setting times the sensor rating gives the pickup current. A setting of twice the maximum train current or feeder rating is often used in transit systems. A 500A sensor and 1X setting typically serves as a reverse current protection on main circuit breakers.

Long Time Function

The time delay function provides a definite time selective operation for coordination. Protection against low current arcing faults that are below the protected zone of conventional AC overcurrent devices is provided with the Type 76 overcurrent relays. This function is particularly suited to transit systems where the load usually fluctuates. The settings depend on the load current profile and the train acceleration time.

Rate-Of-Rise Detector

Faults, especially arcing faults at the end of a track-section, cannot usually be detected by overcurrent devices since trains starting in the section will often draw more current than the remote fault. If left undetected, the arc may cause erosion of the track and elevated structure. These considerations, as well as those involving personnel safety, require fast and reliable isolation of these faults.

The Rate-of-Rise Detector of the type ITE-76 overcomes the problems associated with overcurrent devices. In most cases, protection can be provided against faults in the most remote section, even though the fault current is less than load currents.

The choice of relays and proper settings can be shown by the following example: A typical DC distribution system for a transit system might consist of several rectifiers, each rated 8000A dc continuous. The tracks (or catenaries) are supplied through 4000A dc feeder breakers, with 4000 amp 50 mV sensors.

Assume the track resistance to be .04 ohm per mile total, and the track inductance to be .0016 henry per mile, giving a circuit time constant ($T_1=L/R$) of .04 seconds. Also assume that the longest track section is 2.5 miles.

The various trains in service in modern transit systems require peak starting currents varying in the range of 750 to 1200 amperes per car. These figures apply to both chopper and cam-type starters. For a six car train, an average peak can be higher if trains can start simultaneously. Safe practice is to allow for two trains, or 12 KA.

Allowing for 200V arc-drop, an arcing fault at the far end of the 2.5 mile section produces:

$$I_F = \frac{\overline{E_1} - V_a}{r_1 x} = \frac{600 - 200}{.04 \times 2.5} = 4 \text{ kA}$$

Since the load current is higher than the fault current, this application requires the R/R Detector. The R/R circuit initiates a timing cycle every time the load or fault current rate-of-rise is above its pickup setting. If the rate-of-rise drops below the setting prior to the expiration of the selected delay time, fast resetting of the timer prepares the relay for the next cycle. Otherwise, the relay times out and produces the trip output.

The relay has a signal filter to suppress 360-720HZ current ripple of transit rectifiers. Rate-of-decay or negative R/R of the current is rejected by the detector.

In applying the R/R Detector, a compromise must be made between its reach and security against nuisance trips on train-starts.

Greatest security against nuisance trips on train starts is provided with the longest time delay setting. To determine whether this will obtain a reach adequate for proper system protection, use this time delay value for T in the following equation.

With the rate-of-rise delay T set at .1 second, and rate-of-rise pickup DI at 8 kA/sec., the reach is approximately

$$X = \frac{E_1 - V_a}{L_1 \ (DI)} e^{-T/T_1}$$

$$= \frac{600}{1.6 \times 8} e^{-.1/.04}$$

$$= 3.85 \text{ miles}$$

So the detector will reach beyond the end-zone, and clear the minimum fault condition.

The settings can be made several ways, since the reach is determined by both T and DI. Good results are obtained by assuming a DI, then calculating the proper T from the following equation:

$$T = T_1 \ln \left(\frac{I_1}{T_1} \times \frac{1}{DI}\right)$$

Assume DI = 12kA per second. The arcing fault at 2.5 miles gives I_1 = 4kA, and T_1 = .04, therefore, in order to just see this fault, set

$$T = .04 \ln \left(\frac{4}{.04} \times \frac{1}{12}\right)$$

$$= .08 \text{ seconds}$$

The above calculations are based on ideal conditions. Consideration should be given to current rate-of-rise and its duration under the following dynamic load conditions and the settings matched to the actual operating conditions of the particular system:

1. Initial inrush current to charge vehicle filter capacitors.
2. Step current and its decay during acceleration of cam-controlled cars.
3. Transfer from series to parallel motor conditions.
4. Track cross-over and gap effects.
5. Manual power cut back and restoration in chopper-controlled cars at 30-50 MPH.
6. Fault current in trolley systems with short time constants.
7. Regeneration power absorbtion in some systems.

Recapping the parameters used in the above example:

L = track inductance (mH per mile)

R = track resistance (ohms per mile)

T_1 = L/R = circuit time constant (msec)

T = time delay setting, rate-of-rise element

E = system voltage

Va = arc voltage

X = distance to fault (miles)

I_F = fault current (kiloamps)

DI = rate-of-rise of fault current (KA/sec)

Specifications

Input Signal : From Hall Effect Sensor, nominal
50mV dc at sensor rating.

Max Continuous Input : Greater than 100x nominal.

Control Power : 125Vdc nominal, 140Vdc max,
@ 0.05A max standby.

Output Circuit Rating (at 125Vdc) : Thyristor (SCR) Output:
30 amps DC for 0.1 second
5 amps DC for 1 second.
1 amp DC continuous

Contact Output:
3 amps continuous
1 amp opening resistive
0.3 amp opening inductive

The following apply to the thyristor output circuit:

a. Be sure the trip circuit is interrupted by an "a" contact to remove high currents. Thyristor output circuits have inherently high momentary current ratings and low continuous current ratings. Never exceed the ratings.

b. Load (trip coils or auxiliary relays) must draw at least 0.10 amps to insure operation. SCR's require a minimum current to remain conducting after triggering. Place resistance in parallel with a low current coil to guarantee the holding current if necessary.

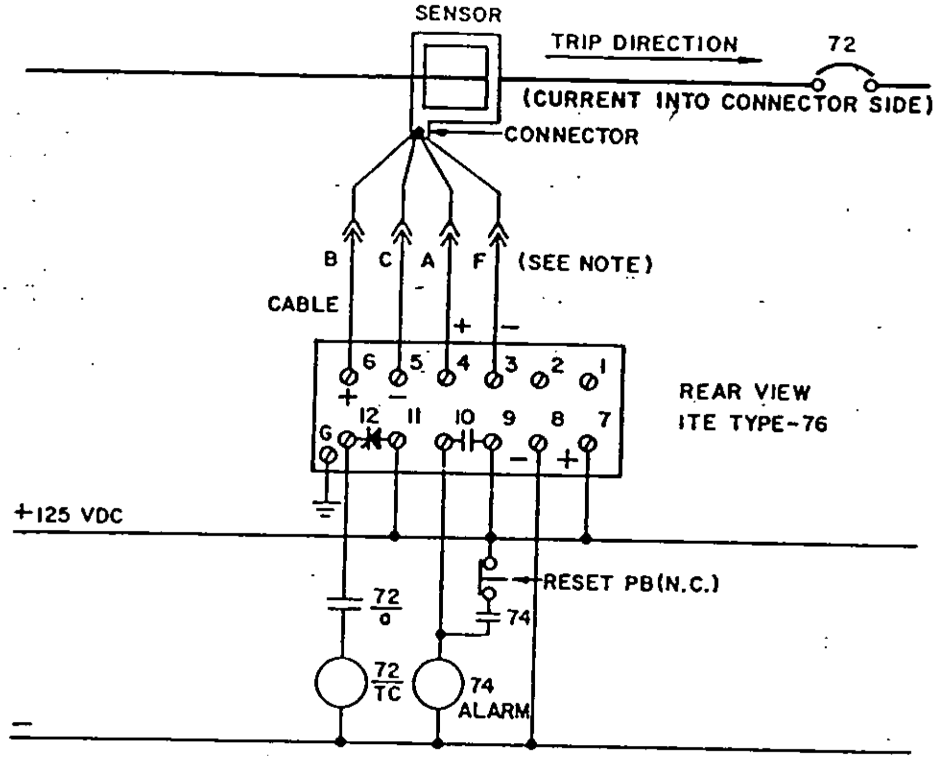
Temperature	:	Nominal	25°C Ambient
		Addition ± 5% Tolerance	-15°C to +55°C
		Must Operate	-30°C to +70°C
Tolerances	:	Rate of Rise Pickup Time Pickup Time Delay Instantaneous Pickup	±10 percent
		Rate of Rise Time	

a) For input signal from 100 to 150 pct of pickup, Time Tolerance will be ±20 pct or 20 ms, whichever is greater.
b) For input signal above 150 pct of pickup, Time Tolerance will be ±10 pct or 10 ms, whichever is greater.

Characteristics of Common Units

Catalog Number	Rate-of-Rise Function	Instantaneous Function	Time Delay Function
206A2240	--	*	--
206C2240	--	--	*
206D2240	*	--	--
206F2240	*	*	*
206G2240	*	*	--
206H2240	--	*	*

Rate of Rise Function: Pickup 0.2 - 4x Sensor Rating. Delay 0.05 - 0.4 sec.
Instantaneous Function: Pickup 1, 2, 3, 4x Sensor Rating.
Time Delay Function: Pickup 0.5, 0.75, 1.0, 1.25x Sensor Rating. Delay 5, 10, 15, 20 seconds.

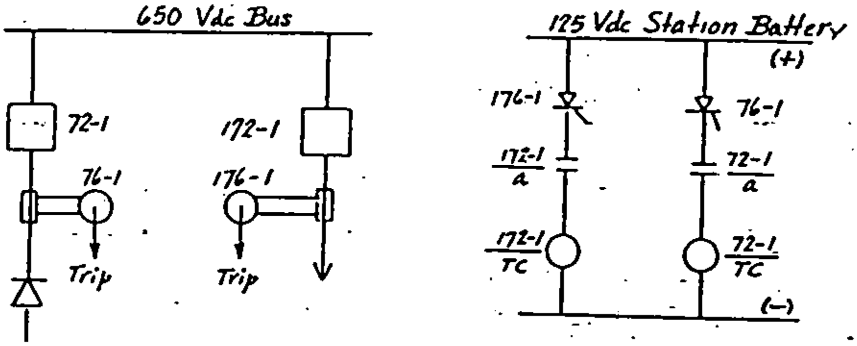


NOTE: FOR REVERSE TRIP DIRECTION, REVERSE B & C(B TO 5, C TO 6)

FIGURE 2 EXTERNAL CONNECTIONS (TYPICAL)

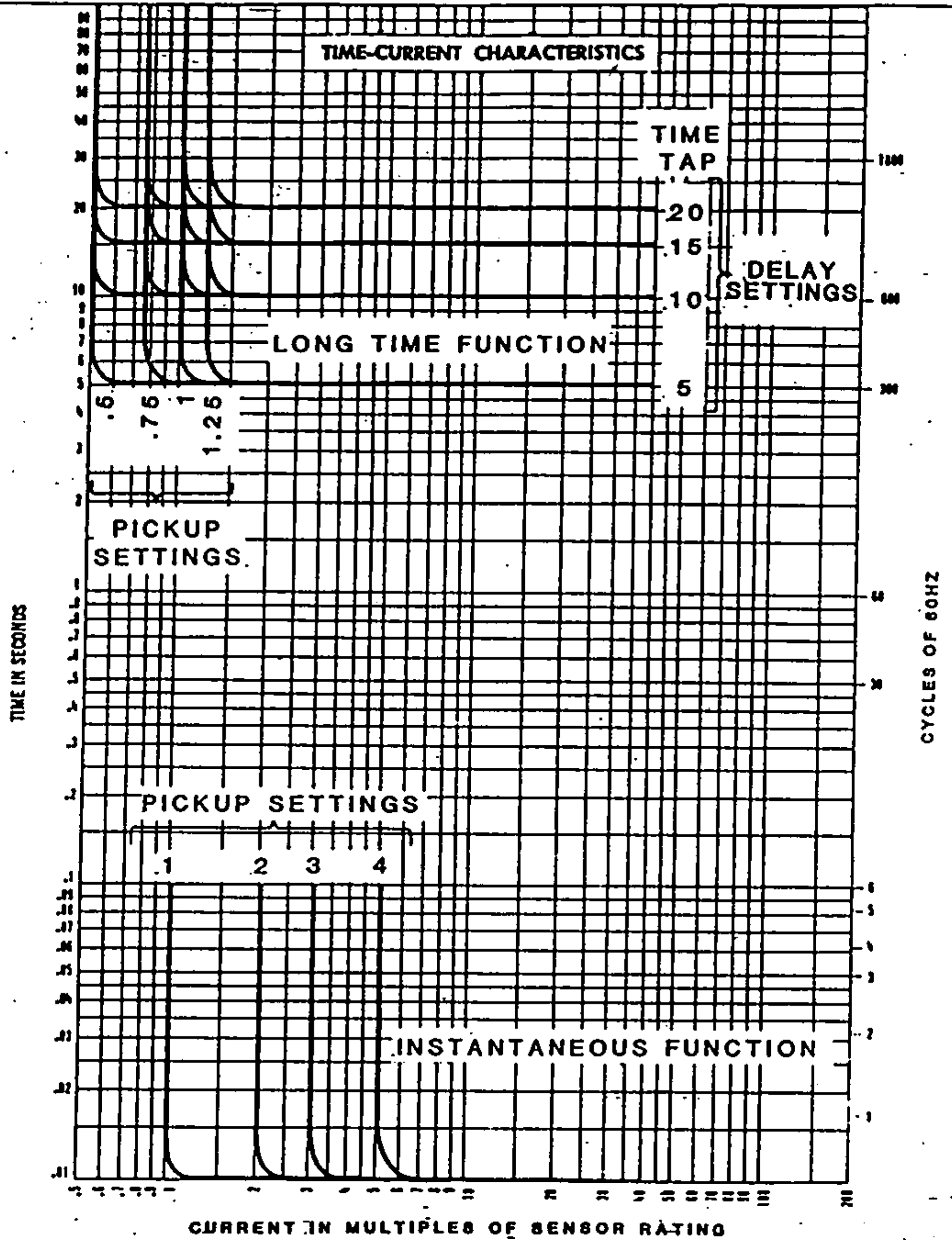
TYPE ITE-76

FIGURE 3 - TYPICAL APPLICATION



DEVICE LEGEND

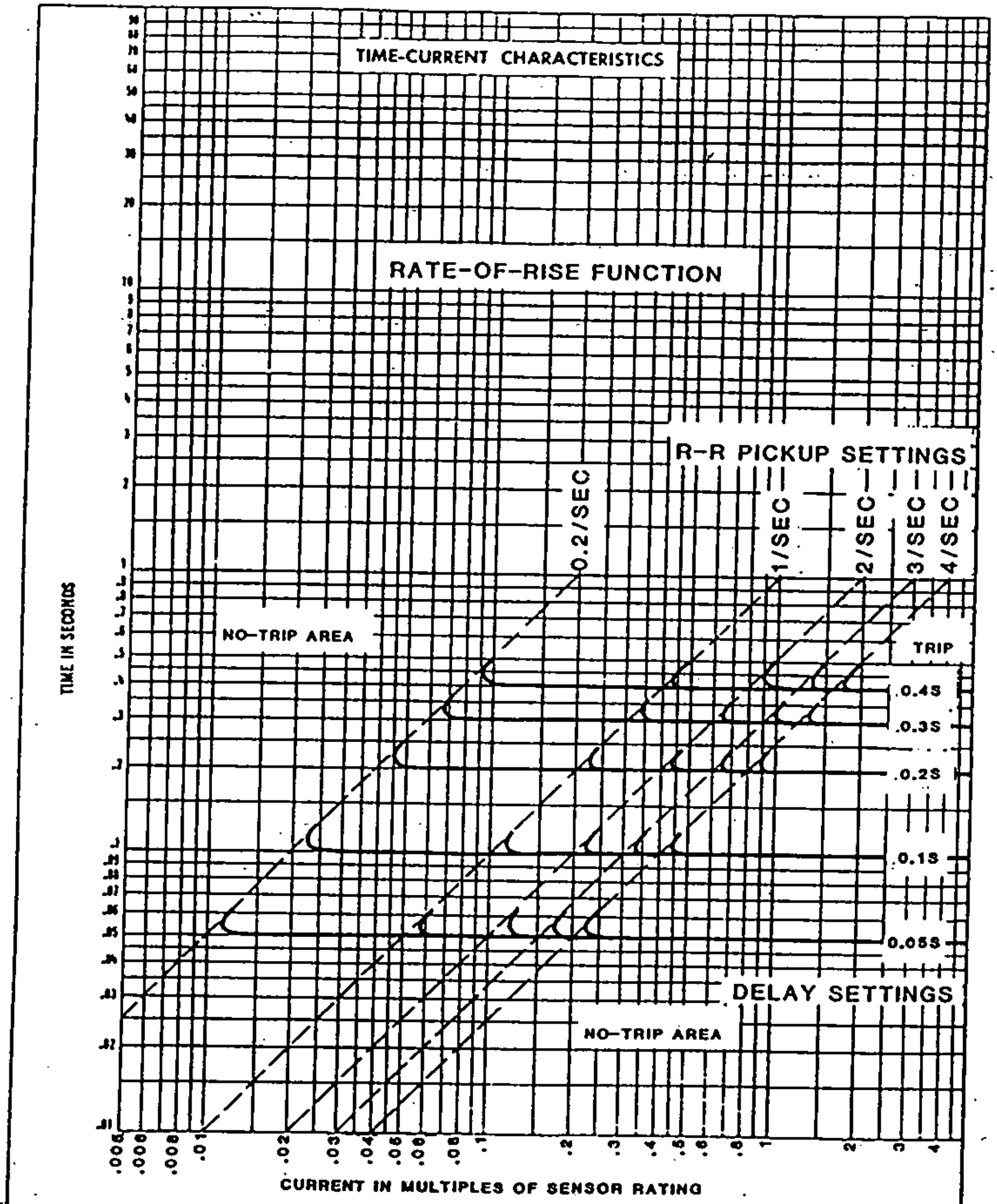
72	**Cathode Circuit Breaker**
172	**Feeder Circuit Breaker**
76-1	**Type ITE-76 , with Instantaneous Only. Trip Direction as shown**
176-1	**Type ITE-76 , with Rate of Rise Detector Only. Trip Direction as shown.**



D.C. OVERCURRENT RELAY
TYPE ITE-76
BBC BROWN BOVERI, INC.

SEPT. 22,1986

605658



D.C. OVERCURRENT RELAY
TYPE ITE-76
BBC BROWN BOVERI, INC.

SEPT. 23,1986

605659

Note: the above figure is not a "conventional" time-current characteristic, as would be used in coordination work. Rather, it is an attempt to illustrate the Pickup and Time settings associated with the Rate-of-Rise function.

TESTING

1. MAINTENANCE AND RENEWAL PARTS

No routine maintenance is required on these relays. Follow test instructions to verify that the relay is in proper working order. We recommend that an inoperative relay be returned to the factory for repair; however, a schematic diagram is available on request for those who wish to attempt repairs.

A circuit card extender is available which is helpful when calibrating or troubleshooting. The ITE-76 uses the 18 point extender, catalog number 200X0018.

Drawout circuit boards of the same catalog number are interchangeable. Removing or installing a circuit board with the unit in service may cause an undesired operation. The board is withdrawn by using the metal pull knobs on the front panel. The circuit board is identified by the catalog number on the front panel and a serial number stamped on the bottom of the board.

2. HIGH POTENTIAL TESTS

High voltage insulation tests are not recommended for the relay circuits. The relay has been tested at the factory. If a control wiring insulation test is required, withdraw the circuit board from the case (partial withdrawal to break the printed circuit connections is sufficient).

3. BUILT-IN TEST FEATURE

Test should be made on a de-energized main circuit. If test must be made on an energized circuit, be sure to take all necessary precautions. Control power must be available to make this test.

The built-in test is provided as a convenient functional test of the relay and associated trip circuit. The test function works as follows: when you depress the button labelled TRIP, the pickup circuit of the relay is actuated. The output contacts operate to trip the associated breaker, and the target is displayed. The test button must be held down continuously for the operating time set on the relay in order to obtain an operation.

Inst. Test

Set the INST pickup setting to 1 P.U. Push the trip test button. This will simulate an overcurrent condition which will cause an instantaneous breaker trip. The instantaneous target will show orange.

R/R Test

Set the R/R pickup and R/R delay to any setting. Set the INST pickup setting at 4 P.U. Push the trip test button. This will simulate a rate-of-rise fault condition which will cause a breaker trip. The R/R target will show orange.

Be sure to return dials to original positions at the conclusion of these tests.

4. ACCEPTANCE TESTS

Mounted in Switchgear

Verification of trip points with an energized main circuit by lowering the trip settings can only be done in some industrial DC supply applications with constant loads. Load currents in transit systems fluctuate and normally can not be preset. Thus, a high current DC current supply may be needed if a sensor and relay calibration check is required. In the latter case, calibration of the instantaneous trip can be performed as follows:

Set the instantaneous pickup setting on the 2X position. All other settings located on the front panel should be set at maximum values.

Apply test current of twice sensor rating to the main circuit. Slowly turn the Inst. calibration potentiometer R23 (internal) CCW until the relay just operates. Decrease the amperes into the main circuit and check the pickup by gradually increasing the amperes. Touch up the calibration adjustment until pickup occurs at exactly twice sensor rating. NOTE: 18-pt. extender boards for this and other tests can be ordered from BBC.

Bench Test

INST - PICKUP

1. Set inst dial to required value.
2. With DC control power off, set signal voltage to 95% of the trip value, in millivolts of DC. (1x = 1 per unit = 50mv dc)
3. With DC control on, apply test voltage. The relay should not trip. (i.e., no inst target indication)
4. With DC control voltage off, set signal voltage to 105% of pickup value. Apply DC.
5. Check for a target indication. Remove test signal. Reset target.
6. Internal potentiometer R23 can be used to trim this operating point.

RATE OF RISE - PICKUP

1. Set R/R dial to 1 PU. Set R/R time dial to 0.05 sec.
2. With DC off, (adjust the sawtooth output of a signal generator) to 47.5mv/sec. (95% of required value.) Use a frequency of 1Hz on the signal generator.
3. With DC control voltage on, apply test signal. The relay should not trip. (i.e., no R/R target indication)
4. With DC off, adjust test signal to 50mv/sec.
5. With DC on, apply sawtooth. The relay should trip giving an R/R target.
6. Reset target by pressing the reset pushbutton.
7. The rate-of-rise pickup dial is continuously adjustable. Therefore, the relay may be calibrated for any desired pickup setting by repeating steps 1-6 for that value.

RATE OF RISE - TIME CURVE

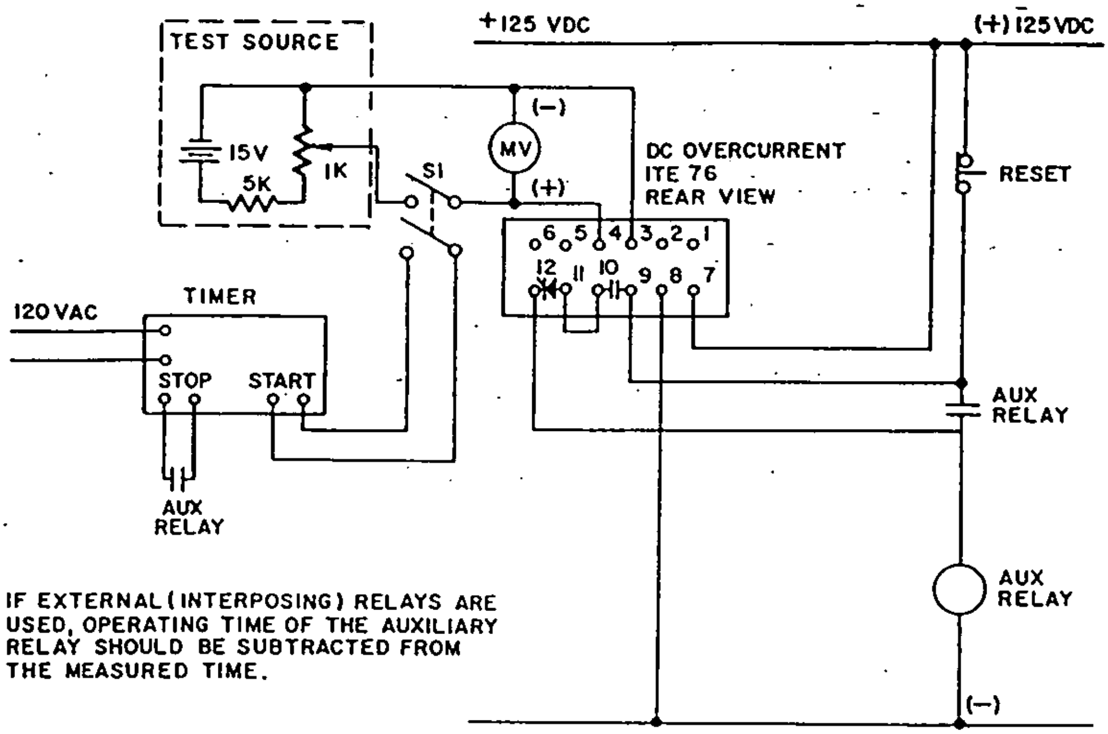
1. Set R/R delay dial to maximum position, 0.4 seconds.
2. With DC off, set R/R pickup dial to 1 PU.
3. Adjust test equipment for a 100mv/sec. sawtooth.
4. With DC on, apply test sawtooth. The relay should trip in a time within 0.4 seconds ±10%. Check for R/R target indication.
5. Reset target by pressing the reset pushbutton.
6. The R/R Time Delay dial is continuously adjustable. Therefore, the relay may be calibrated for any desired delay by repeating steps 1-6 for the desired setting.

TIME DELAY - PICKUP

1. Set time pickup tap pin to required value. Set delay tap to 5 seconds.
2. With DC control source off, preset test voltage to 95% of pickup value. (1x = 1 per unit = 50mv)
3. With DC source on, apply test voltage. No trip should occur. (Wait 20 seconds.)
4. With DC off, preset test voltage to 105% of pickup value.
5. With DC on, apply test voltage. The relay should trip. (Allow sufficient time.)

TIME DELAY - DELAY CURVE

1. Set time delay pickup dial to required value.
2. Set time delay dial to required value, per time current curves.
3. With DC off, preset test voltage to 120% of PICKUP value.
4. With DC on, apply test voltage. The relay should trip in the set time ±10%.



IF EXTERNAL (INTERPOSING) RELAYS ARE USED, OPERATING TIME OF THE AUXILIARY RELAY SHOULD BE SUBTRACTED FROM THE MEASURED TIME.

FIGURE 4 CALIBRATION TEST SCHEMATIC (Typical)

NOTES:

1. For testing rate-of-rise function, test source must be replaced with a signal generator that provides a sawtooth output waveform. As an alternate, some oscilloscopes provide a sweep signal output (sawtooth wave) that can be used as the signal source.

2. Operating time of the auxiliary relay used in the test scheme should be subtracted when making timing tests.

BBC
BROWN BOVERI

BBC Brown Boveri, Inc.
35 North Snowdrift Road
Allentown, PA 18106
Phone: (215) 395-7333

Issue A (12/86)
Supersedes 18.5.7-2

SENSOR, SINGLE LEG ASSY.

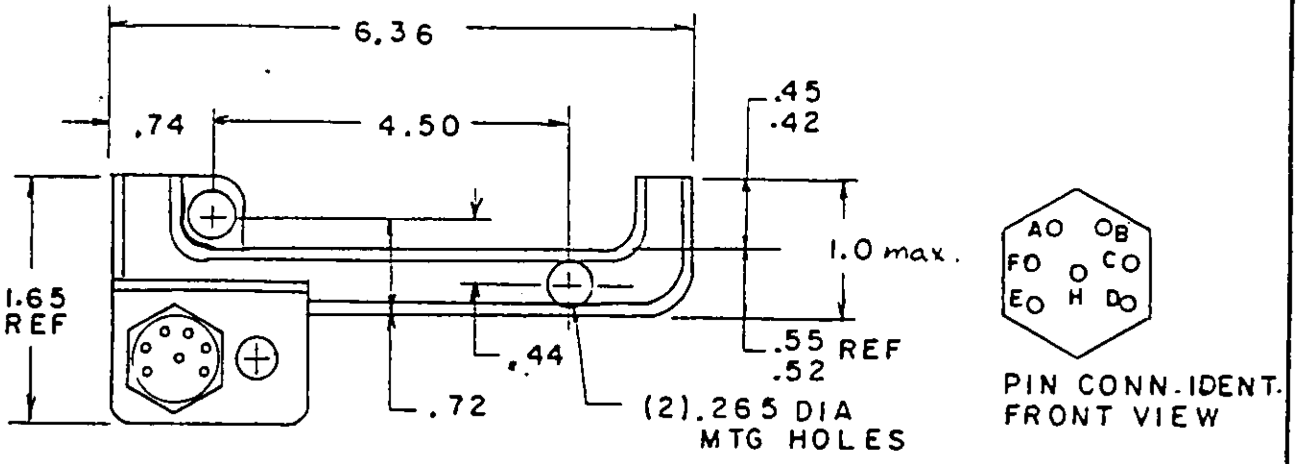
BBC
BROWN BOVERI

Brown Boveri Electric, Inc.
Manufacturer of I-T-E Electrical Power Equipment

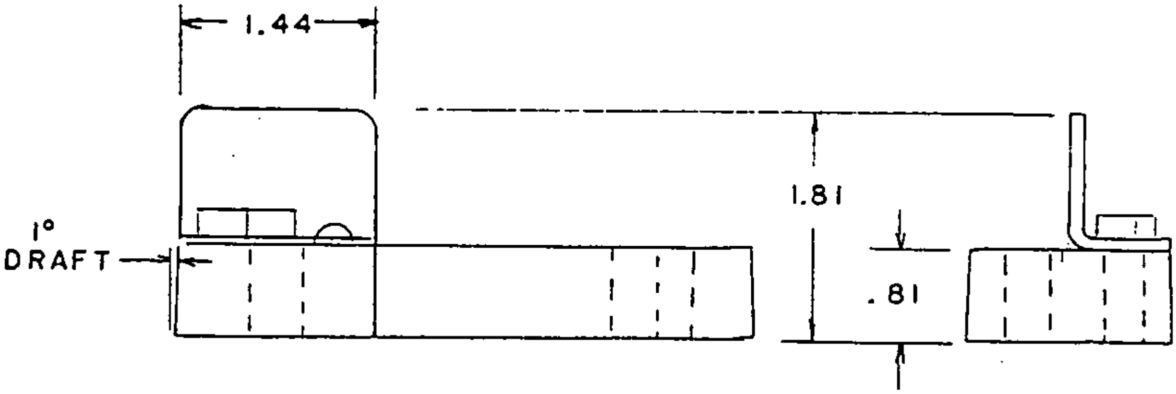
609544	REV. 1		
SIZE 1	SHEET NO.	CONT. ON	
NEXT ASSY.	BY DEA	CHD.	APP. CLB
P.O.	DATE 12-9-83	DATE 12/12/83	DATE 12/12/83
		MICRO.	S.O.

TYPE	PROD.	CLASS	
			THIS DRAWING IS THE PROPERTY OF BROWN-BOVERI ELECTRIC, INC. AND CONTAINS PROPRIETARY AND CONFIDENTIAL INFORMATION WHICH MUST NOT BE DUPLICATED, USED, OR DISCLOSED OTHER THAN AS EXPRESSLY AUTHORIZED BY BROWN-BOVERI ELECTRIC, INC.

STANDARD TOLERANCE INFO. ON DR. 52016 DIMENSIONS ARE IN INCHES
TOLERANCES – UNLESS OTHERWISE SPECIFIED – 3 PL. DEC. ± 2 PL. DEC. ±



EPOXY MOULDING OUTLINE



NOTE;

1- WHEN MOUNTING USE 1/4-20 OR SMALLER NON-MAGNETIC HARDWARE, AND (1) 612310-001 MTG CLIP OR SIMILAR NON-MAGNETIC PLATE.

2- ALL DIMENSIONS FROM BOTTOM OF MOULDING (TO INCLUDE 1° DRAFT).

						5			
						4			
						3			
				/		2	609877-K2	SENSOR, CPC-4000-6	
					/	1	609877-K1	SENSOR, CPC-5000-8	
6	K5	K4	K3	K2	K1	PC. NO.	DRAWING NUMBER	DESCRIPTION	CODE
						REV.			

REVISIONS
DIMR. OF ALL DIM'S. TO BOTTOM OF MOULD. 12-10-83

FORM BB-828

INSTALLATION AND OPERATING INSTRUCTIONS

TEMPERATURE CONTROLS

MODELS 2E206, 2E207 & 2E728

FORM
5S1421
05881
0383/490

DAYTON ELECTRIC MANUFACTURING CO. CHICAGO 60648

READ INSTRUCTIONS CAREFULLY BEFORE ATTEMPTING TO INSTALL OR OPERATE THE DAYTON TEMPERATURE CONTROLS!
RETAIN INSTRUCTIONS FOR FUTURE REFERENCE.

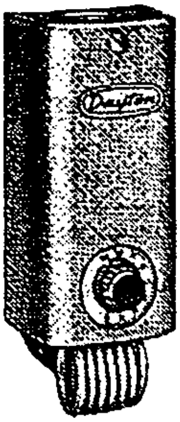


Figure 1

Description

The single stage Models 2E206 (SPDT) and 2E728 (SPST) and the two stage Model 2E207 (SPDT) are designed to control automatic ventilation or heating systems. The 30° to 110°F temp range permits use for many space applications.

NOTE: Not for use where a National Electrical Code Article 547 approved control is required.

The enclosed switches are protected against dust and other foreign materials. A compact helical temperature element, treated to minimize corrosion, is firmly attached to the exterior of the case and when the thermostat is mounted with bulb pointed down, it is protected from falling objects, dirt, etc.

Specifications

MODEL 2E728: One SPST switch (one set of contacts opens on temperature drop).

MODEL 2E206: One SPDT switch (one set of contacts opens on temperature rise as the other set closes simultaneously).

MODEL 2E207: Two SPDT switches, with one-stage operating 3°F higher than the other stage.

Range: 30° to 110°F. (140°F. maximum overrun temperature).

Differential: Approximately 3½°F. (Each switch has this differential on Model 2E207).

Temperature between stages: (Model 2E207) This difference is fixed; the low stage makes contacts R to Y at the dial setting while the high stage makes contact approximately 3°F above the dial setting.

Case: 062" cold rolled steel. Gray baked enamel finish.

Cover: .025" cold rolled steel. Gray baked enamel finish.

Contact Unit: Snap-acting contacts in dust-tight tamper proof enclosure.

UL Listed.

ELECTRICAL RATINGS

MODELS 2E206 & 2E728

<table>
<tr><th colspan="2">Voltage, AC</th><th>120</th><th>208</th><th>240</th><th>277</th></tr>
<tr><td colspan="2">Full load amps</td><td>16.0</td><td>9.2</td><td>8.0</td><td>—</td></tr>
<tr><td colspan="2">Locked rotor amps</td><td>96.0</td><td>55.2</td><td>48.0</td><td>—</td></tr>
<tr><td colspan="2">Model 2E728 SPST:
Non-inductive or resistance load amps* (not lamp loads)</td><td>22.0</td><td>22.0</td><td>22.0</td><td>22.0</td></tr>
<tr><td rowspan="2">Model 2E206:
Non-Ind.</td><td>When connected — SPST</td><td>22.0</td><td>22.0</td><td>22.0</td><td>22.0</td></tr>
<tr><td>When connected — SPDT</td><td>16.0</td><td>9.2</td><td>8.0</td><td>7.2</td></tr>
<tr><td colspan="2">Pilot duty</td><td colspan="4">125 VA, 24/600 V.A.C.</td></tr>
</table>

*SPST RATING.

MODEL 2E207

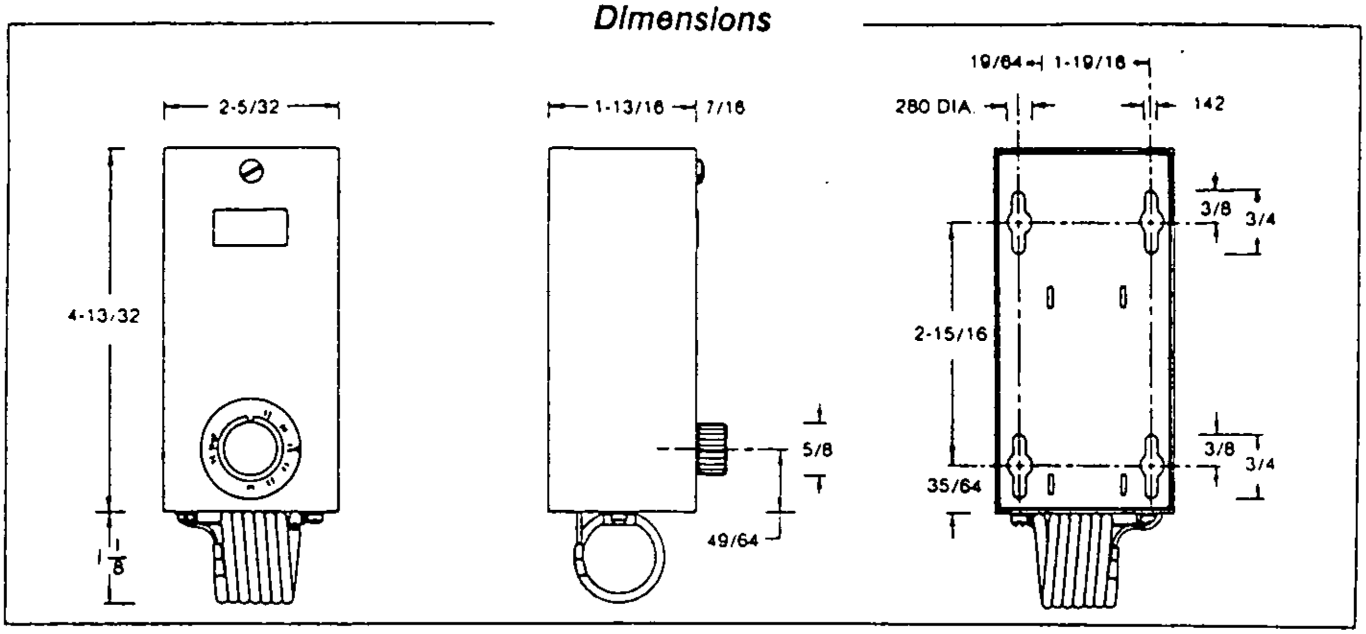
Voltage, AC	120	208	240
Full load amps	16.0	9.2	8.0
Locked rotor amps	96.0	55.2	48.0
Non-inductive or resistance load amps (not lamp loads)	16.0	9.2	8.0
Pilot duty	125 VA, 24/277 V.A.C.		

NOTE: When used as a two circuit switch, the total connected load must not exceed 2000 VA.

General Safety Information

1. Disconnect power supply before wiring connections are made to prevent possible electrical shock or damage to equipment.
2. All wiring should conform to the National Electrical Code and local regulations.
3. Loads exceeding the rating of the thermostat should be handled with a relay or motor starter.
4. These thermostats are designed to function as operating controls only, and do not have temperature limit ratings. Where critical or high value products are to be maintained, an approved temperature limit should be wired in series with these thermostats. In less critical applications, a second thermostat with alarm contacts can be used to provide redundancy.

Dimensions



Performance specifications appearing herein are nominal and are subject to accepted manufacturing tolerances and application variables.

Figure 2 — Dimensions

Installation

LOCATION

Mount control 5' to 6' above the floor where it will be exposed to the average temperature of the controlled space. Do not mount control where it will be affected by unusual heat or cold such as directly exposed to body heat or in sunlight. Avoid locations near a door, window or other opening. Do not mount on an outside wall.

MOUNTING

CAUTION: Do not dent or deform the sensing bulb of this control. A dent or deformation will change the calibration and cause the control to cycle at a temperature lower than the dial setting.

CAUTION: On rough mounting surface use top two mounting holes only. When you mount this control on an uneven surface and pull all four mounting screws down tight, you can twist the case enough to affect thermostat calibration and operation.

WIRING

All wiring should be done in accordance with applicable codes, ordinances and regulations, Figures 3, 4, and 5 illustrate typical wiring of Models 2E206 and 2E728 for control of heating, cooling, and a combination heating-cooling control system.

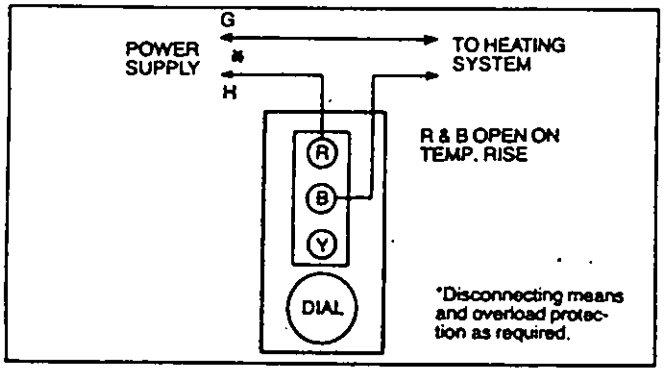


Figure 3 — Model 2E206 in typical heating control circuit.

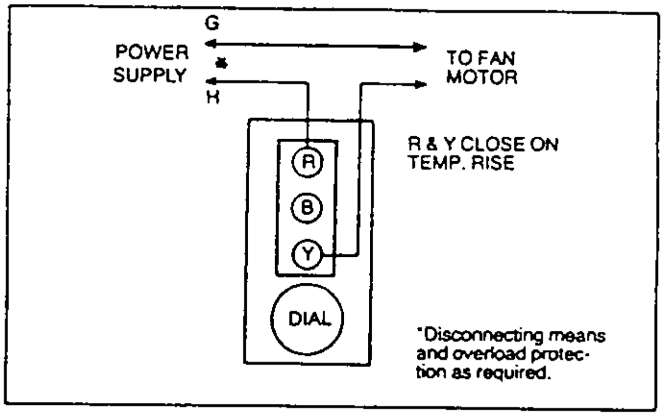


Figure 4 — Models 2E206 & 2E728 in typical ventilating or cooling control circuit. (Terminal B is not used on Model 2E728.)

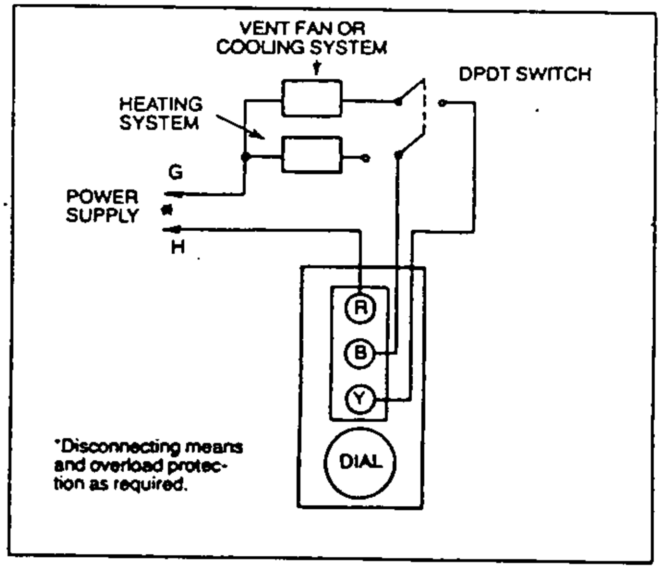


Figure 5 — Model 2E206 in control of heating and ventilating systems.

Installation (Continued)

Figure 6 shows typical wiring for the control of a two speed ventilating fan. When control temperature element reaches the dial settings of Model 2E207, the low temperature switch starts the fan on low speed. If the space temperature continues to rise, the high temperature switch supplies power to the high speed motor winding while disconnecting the low speed winding.

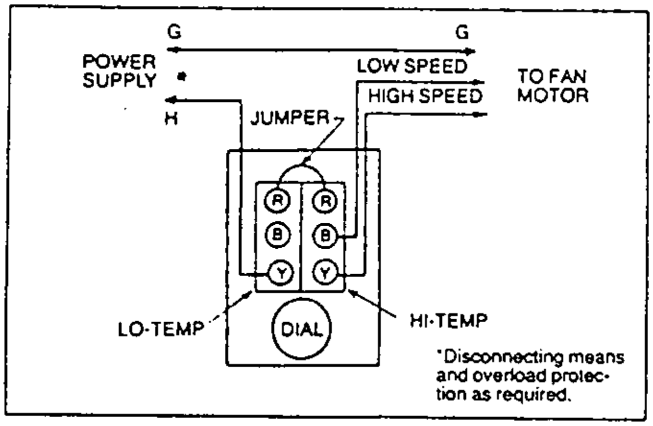


Figure 6 — Model 2E207 in typical two-speed ventilating fan control circuit.

Figure 7 shows Model 2E207 in a typical hook-up for a two-volume fan application. The fan will start when the temperature element reaches the dial setting. If the temperature continues to rise, the damper motor will be energized by the high temperature switch.

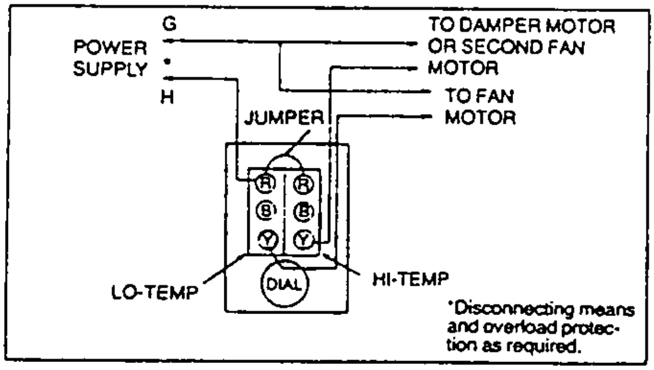


Figure 7 — Model 2E207 in control of single speed ventilating fan and volume-increase damper motor.

Model 2E207 can also be used to control a combination heating and ventilating or cooling system, as shown in Figure 8. A temperature increase to the dial setting will turn off the heating system when the R-B contacts of the low temperature switch break. An increase in temperature of about 3°F will turn on the fan or cooling system through the R-Y contacts of the high temperature switch.

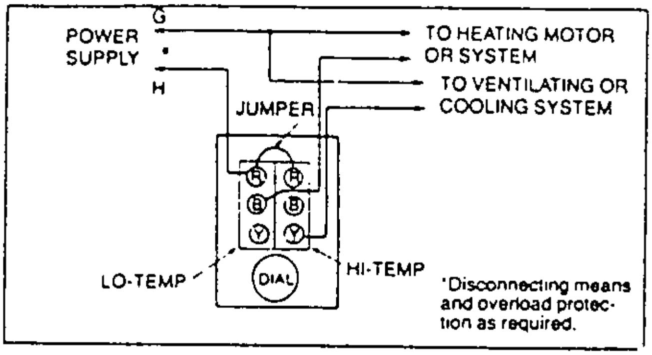


Figure 8 — Typical wiring of heating and cooling devices to Model 2E207 two-stage thermostat (automatic changeover).

Figure 9 illustrates typical wiring of Model 2E207 for control of two stages of heating. As the space temperature decreases to the dial setting, the high temperature switch will make R-B turning on the first stage of heating. If the temperature continues to drop (about 3°F.) the low temperature switch will make R-B turning on the second stage of heating.

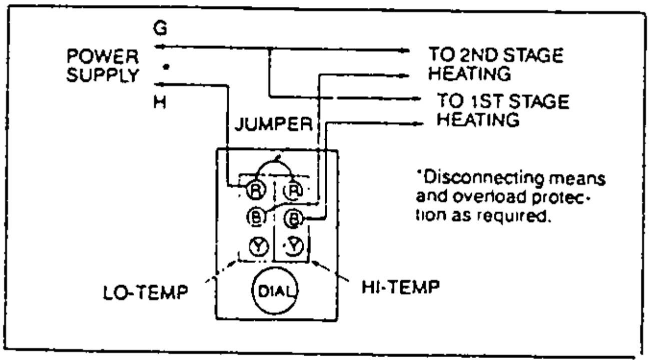


Figure 9 — Typical wiring of two-stage heating.

CHECKOUT PROCEDURE

Before leaving the installation, a complete operating cycle should be observed to see that all components are functioning properly.

Check for correct operation in the following manner:

1. Models 2E206 & 2E728 — Ventilating or Cooling System: Turn dial clockwise to a setting above space temperature. Fan or cooling system should be off. When dial is turned counterclockwise, the fan or cooling system should turn on approximately at the dial setting.

   Model 2E206 — Heating System: Turn dial clockwise above the space temperature; the heating unit should be on. When dial is turned counterclockwise, the heating unit should turn off approximately at the dial setting.
2. Model 2E207. If hook-up is similar to Figure 6, fan should start at approximately space temperature and should change to high speed as the dial is turned counterclockwise to a lower temperature setting. If wiring is similar to Figure 7, the damper should open as the dial is turned counterclockwise. The devices should act in reverse sequence when the dial is turned clockwise.

Operation

Figure 10 illustrates the operation of Model 2E207. On a temperature increase to the dial setting, the circuit between R and Y of the low stage switch (RYL) closed. Simultaneously the circuit between R and B (RBL) opens. On a further increase in temperature the high stage switch operates and closes (RYH) while simultaneously opening (RBH). The reverse sequencing takes place on a temperature fall.

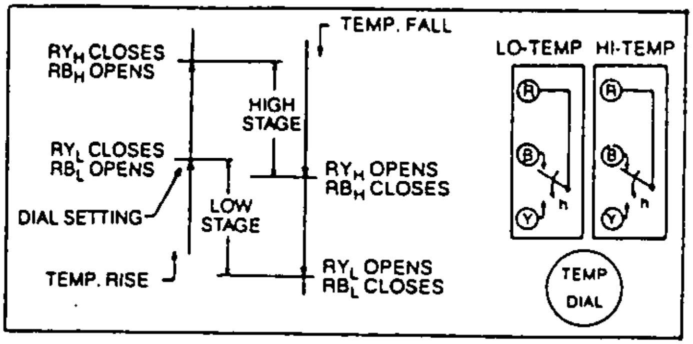


Figure 10 — Operational diagrams of Model 2E207.

Trouble Shooting Chart

MODELS 2E206 & 2E728

SYMPTOM	POSSIBLE CAUSE(S)	CORRECTIVE ACTION
Cooling or fan does not operate	1. Improper wiring 2. Thermostat dial set above space temperature	1. Check wiring. 2. Set dial to lower temp.
Cooling or fan runs continuously	1. Improper wiring 2. Thermostat dial set below space temp.	1. Check wiring. 2. Set dial to higher temp.

MODEL 2E206

SYMPTOM	POSSIBLE CAUSE(S)	CORRECTIVE ACTION
System operates in reverse.	Improper wiring	Check wiring.
Heating unit does not operate.	1. Improper wiring 2. Thermostat dial set below space temp.	1. Check wiring. 2. Set dial to higher temp.
Heating unit runs continuously	1. Improper wiring 2. Dial set above space temperature	1. Check wiring. 2. Set dial to lower temp.

MODEL 2E207

SYMPTOM	POSSIBLE CAUSE(S)	CORRECTIVE ACTION
Cooling or fan does not operate.	1. Improper wiring 2. Thermostat dial set too high	1. Check wiring. 2. Adjust dial to lower setting.
Cooling or fan runs continuously	1. Improper wiring 2. Thermostat set too low	1. Check wiring. 2. Adjust to higher setting.
Heating does not operate. (Figure 9).	1. Improper wiring 2. Thermostat set too low	1. Check wiring. 2. Adjust thermostat to higher setting. First stage of heating should come on when dial setting equals space temp. As dial is adjusted to higher temp. (3° F.) second stage of heating unit should come on.
Heating system runs continuously	1. Improper wiring 2. Thermostat set too high	1. Check wiring. 2. Adjust to lower setting.
System runs in reverse.	Improper wiring	Check wiring.

LIMITED WARRANTY

Dayton temperature controls, Models 2E206, 2E207 & 2E728, are warranted by Dayton Electric Mfg. Co. (Dayton) to the original user against defects in workmanship or materials under normal use (rental use excluded) for one year after date of purchase. Any part which is determined to be defective in material or workmanship and returned to an authorized service location, as Dayton designates, shipping costs prepaid, will be repaired or replaced at Dayton's option. For warranty claim procedures, see "Prompt Disposition" below. This warranty gives purchasers specific legal rights, and purchasers may also have other rights which vary from state to state.

WARRANTY DISCLAIMER. Dayton has made a diligent effort to illustrate and describe the products in this literature accurately; however, such illustrations and descriptions are for the sole purpose of identification, and do not express or imply a warranty that the products are merchantable, or fit a particular purpose, or that the products will necessarily conform to the illustrations or descriptions.

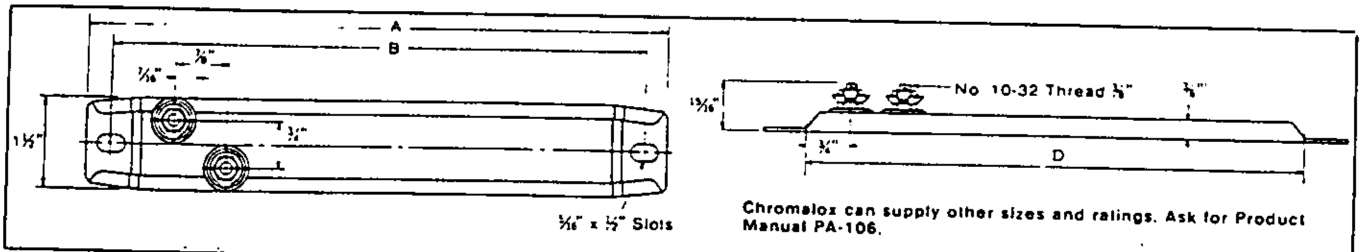
Except as provided below, no warranty or affirmation of fact, expressed or implied, other than as stated in "LIMITED WARRANTY" above is made or authorized by Dayton, and Dayton's liability in all events is limited to the purchase price paid.

Certain aspects of disclaimers are not applicable to consumer products; e.g., (a) some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you; (b) also, some states do not allow limitations on how long an implied warranty lasts, consequently the above limitation may not apply to you; and (c) by law, during the period of this Limited Warranty, any implied warranties of merchantability or fitness for a particular purpose applicable to consumer products purchased by consumers, may not be excluded or otherwise disclaimed.

PROMPT DISPOSITION. Dayton will make a good faith effort for prompt correction or other adjustment with respect to any product which proves to be defective within warranty. For any product believed to be defective within warranty, first write or call dealer from whom product was purchased. Dealer will give additional directions. If unable to resolve satisfactorily, write to Dayton at address below, giving dealer's name, address, date and number of dealer's invoice, and describing the nature of the defect. If product was damaged in transit to you, file claim with carrier.

DAYTON ELECTRIC MFG. CO., 5959 W. HOWARD ST., CHICAGO, ILLINOIS 60648

Type OT—1½" wide
Two off-set bolt terminals
it one end



Chromalox can supply other sizes and ratings. Ask for Product Manual PA-106.

Dimensions—Inches			Rust-resisting iron sheath See pg. 178 for max. sheath temp.					Chrome steel sheath See pg. 178 for max. sheath temp.					
A Overall Length	B Mtg. Hole Center	D Without Mtg. Tabs	Volts	Watts	Watts Per Sq. In.	Catalog Number	Product Code No. (PCN)	Volts	Watts	Watts Per Sq. In.	Catalog Number	Product Code No. (PCN)	Approx. Net Wt. Lbs.
7½	6½	6	120	150	11	OT-715	129314	120	200	15	OT-702	129613	.50
			240	150	11	OT-715	129322	240	200	15	OT-702	129621	.50
8	7	6½	120	150	10	OT-815	129330	120	250	17	OT-802	129630	.56
			240	150	10	OT-815	129349	240	250	17	OT-802	129648	.56
			120	175	12	OT-817	129357	120	400	27	OT-804	129656	.56
			240	175	12	OT-817	129365	240	400	27	OT-804	129664	.56.
10½	9½	9	120	250	10	OT-1025	129373	120	350	15	OT-1003	129672	.75
			240	250	10	OT-1025	129381	240	350	15	OT-1003	129680	.75
			...	...	..	....	......	120	400	17	OT-1004	129699	.88
			...	...	..	....	......	240	400	17	OT-1004	129701	.88
12	11	10½	120	250	8	OT-1225	129390	120	250	8	OT-1202	129710	.88
			240	250	8	OT-1225	129402	240	250	8	OT-1202	129728	.88
			...	...	..	....	......	120	350	14	OT-1203	129736	.88
			...	...	..	....	......	240	350	14	OT-1203	129744	.88
			...	...	..	....	......	120	500	17	OT-1205	129752	.88
			...	...	..	....	......	240	500	17	OT-1205	129760	.88
14	13	12½	120	300	8	OT-1430	129410	120	500	14	OT-1405	129779	1.0
			240	300	8	OT-1430	129429	240	500	14	OT-1405	129787	1.0
15¼	14¼	13¾	120	325	8	OT-1532	129437	120	500	12	OT-1505	129795	1.13
			240	325	8	OT-1532	129445	240	500	12	OT-1505	129808	1.13
17⅞	16⅞	16⅜	120	350	6.5	OT-1835	129453	120	500	10	OT-1805	129816	1.38
			240	350	6.5	OT-1835	129461	240	500	10	OT-1805	129824	1.38
			120	375	7	OT-1837	129470	120	750	15	OT-1807	129832	1.38
			240	375	7	OT-1837	129488	240	750	15	OT-1807	129840	1.38
			120	500	10	OT-1850	129496	120	1000	19	OT-1801	129859	1.38
			240	500	10	OT-1850	129509	240	1000	19	OT-1801	129867	1.38
19½	18½	18	120	350	6	OT-1935	129517	120	500	9	OT-1905	129875	1.5
			240	350	6	OT-1935	129525	240	500	9	OT-1905	129883	1.5
			120	500	8	OT-1950	129533	120	750	13.5	OT-1907	129891	1.5
			240	500	8	OT-1950	129541	240	750	13.5	OT-1907	129904	1.5
			...	...	..	....	......	120	1000	18	OT-1901	129912	1.5
			...	...	..	....	......	240	1000	18	OT-1901	129920	1.5
21	20	19½	120	500	8	OT-2150	129550	120	750	12	OT-2107	129939	1.63
			240	500	8	OT-2150	129568	240	750	12	OT-2107	129947	1.63
23¾	22¾	22¼	120	500	7	OT-2450	129576	120	500	7	OT-2405	129955	1.81
			240	500	7	OT-2450	129584	240	500	7	OT-2405	129963	1.81
			120	750	10	OT-2475	129592	120	750	10	OT-2407	129971	1.81
			240	750	10	OT-2475	129605	240	750	10	OT-2407	129980	1.81
			...	...	..	....	......	120	1000	14	OT-2401	129998	1.81
			...	...	..	....	......	240	1000	14	OT-2401	130008	1.81
			...	...	..	....	......	120	1500	19	OT-2415	129226	1.81
			...	...	..	....	......	240	1500	19	OT-2415	129234	1.81

Specify: Quantity catalog no PCN volts watts strip heaters For additional features (page 179) available for Type OT add without mounting tabs, secondary insulation bushings PCN 255716 protective terminal cover – catalog no OT-AC-1 PCN 129242. set of two ceramic post terminal insulators part no 1-41059 PCN 259805

POTENTIAL TRANSFORMER

Model 465

FREQUENCY:
50 & 60 Hz.

STANDARD SECONDARY VOLTAGE:
120 Volts

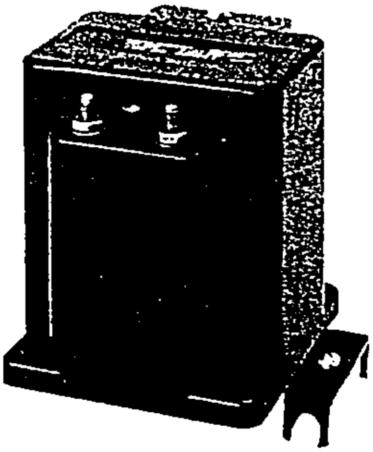
INSULATION CLASS:
600 Volts, 10 Kv. BIL.

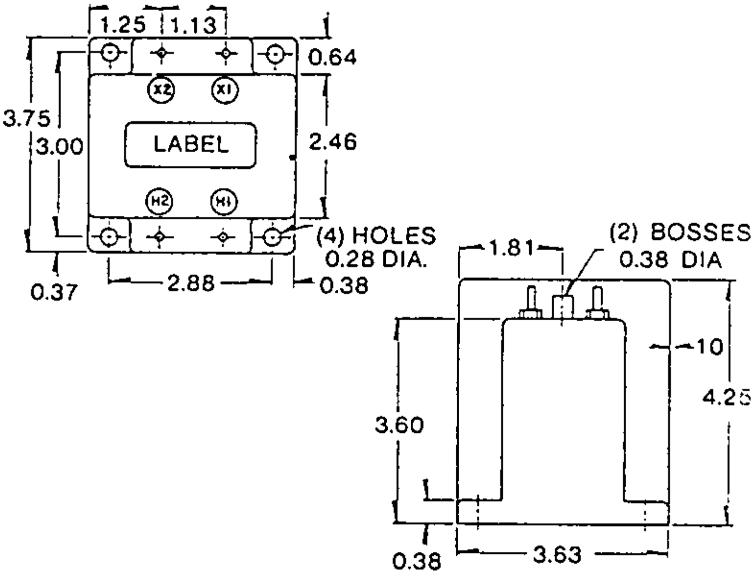
ACCURACY CLASS:
0.6 W., 1.2X at 60 Hz

THERMAL RATING:
150 VA at 30°C amb., 100 VA at 55°C amb.

All models on this page U.L. recognized - file no. E93779.

- Terminals are brass studs No. 10-32 with one lockwasher, flat washer & regular nut.
- The core and coil assembly is encased in a thermoplastic shell and filled with resin.
- These transformers are designed for operation line-to-line. They may also be operated line-to-ground or line-to-neutral, at reduced voltage, (58% of rated volts).
- It is desirable to use the proper size fuse in the secondary to protect the P.T. Use a 1.6 amp fuse with Model 465.
- With three exceptions these transformers are ANSI C57.13 group 1. Those marked * are group 2.
- Other ratios available upon request.
- The model 465-380 is designed specifically for 50 Hz operation.
- This page contains a circle diagram for the estimation of the errors for other than rated burdens. See elsewhere in this P.T. section for a description of its use.
- Approximate weight: 7.75 lbs.





APPLICATION AND ORDERING DATA

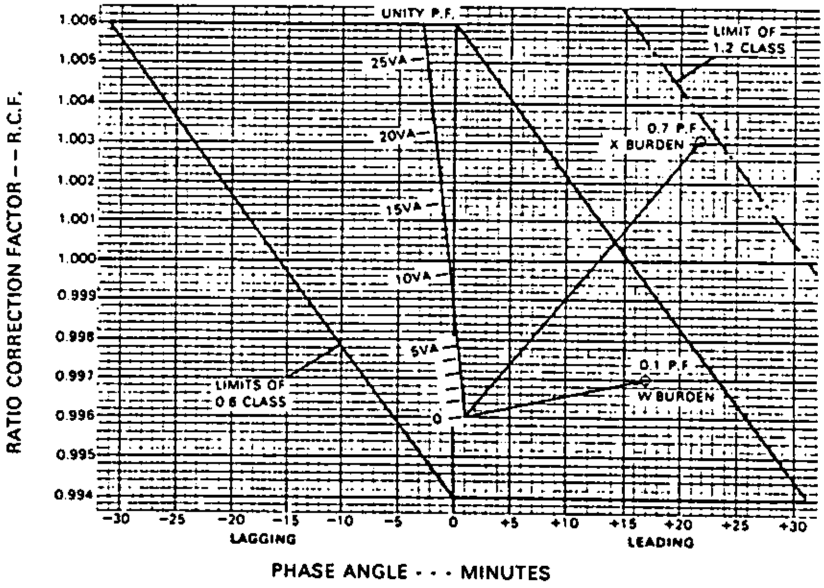
CATALOG NO.	VOLTAGE RATING	TURNS RATIO
465-069	69.4:120	0.58:1
465-120	120:120	1:1
465-208	208:120	1.73:1
465-240	240:120	2:1
465-288	288:120	2.4:1
465-300	300:120	2.5:1
*465-480	480:120	4:1
*465-600	600:120	5:1
*465-380	380:120	3.17:1 for 50HZ

ANSI. C.57.13., burden data....

BURDEN	POWER FACTOR	VOLT—AMPERES	P.F. ANGLE
W	0.1	12.5	84.3°
X	0.7	25.0	45.6°
M	0.2	35.0	78.5°
Y	0.85	75.0	31.8°
Z	0.85	200.0	31.8°
ZZ	0.85	400.5	31.8°

POTENTIAL TRANSFORMER CIRCLE DIAGRAM

THIS GRAPH IS DRAWN FOR A 0.6 P.F. SYSTEM LOAD.



Amp-trap®–Form 101

Semiconductor Fuses

A100P

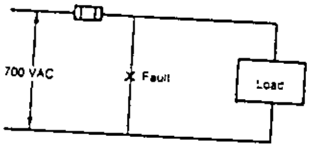


Fig. A

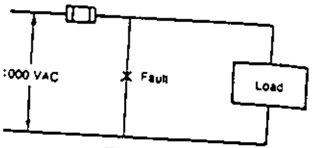


Fig. B

I^2t Data For A100P Fuses—1000 Volts AC

FUSE AMPERE RATING	I^2t DATA (AMPERE² SECONDS) MELTING	I^2t DATA (AMPERE² SECONDS) CLEARING 1 FUSE AT 700VAC (FIG. A)	I^2t DATA (AMPERE² SECONDS) CLEARING 1 FUSE AT 1000VAC (FIG. B)	FUSE AMPERE RATING	I^2t DATA (AMPERE² SECONDS) MELTING	I^2t DATA (AMPERE² SECONDS) CLEARING 1 FUSE AT 700VAC (FIG. A)	I^2t DATA (AMPERE² SECONDS) CLEARING 1 FUSE AT 1000VAC (FIG. B)
	× 10³A²S	× 10³A²S	× 10³A²S		× 10³A²S	× 10³A²S	× 10³A²S
35	.29	1.2	2.2	225	12	48	91
40	.38	1.5	2.9	250	15	59	110
50	.60	2.4	4.5	300	22	86	160
60	.86	3.4	6.5	350	29	110	220
65	1.0	4.0	7.6	400	38	150	290
70	1.2	4.7	8.8	500	60	240	450
80	1.5	6.1	12	600	86	340	650
100	2.4	9.5	18	650	100	400	760
125	3.8	15	28	700	120	470	880
150	5.4	21	41	800	150	610	1,200
200	9.6	38	72	1,000	240	950	1,900

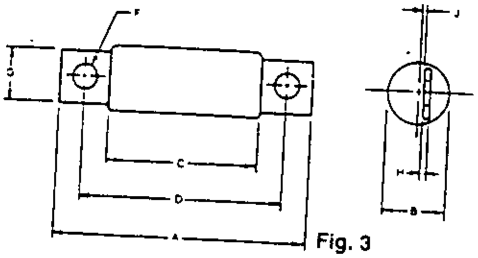


Fig. 3

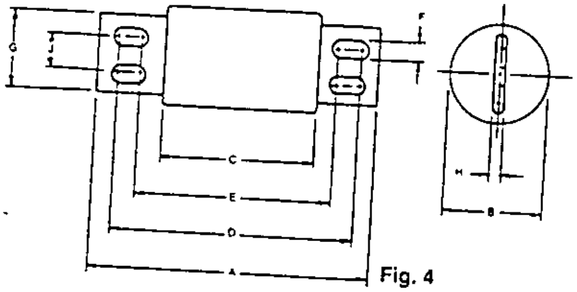


Fig. 4

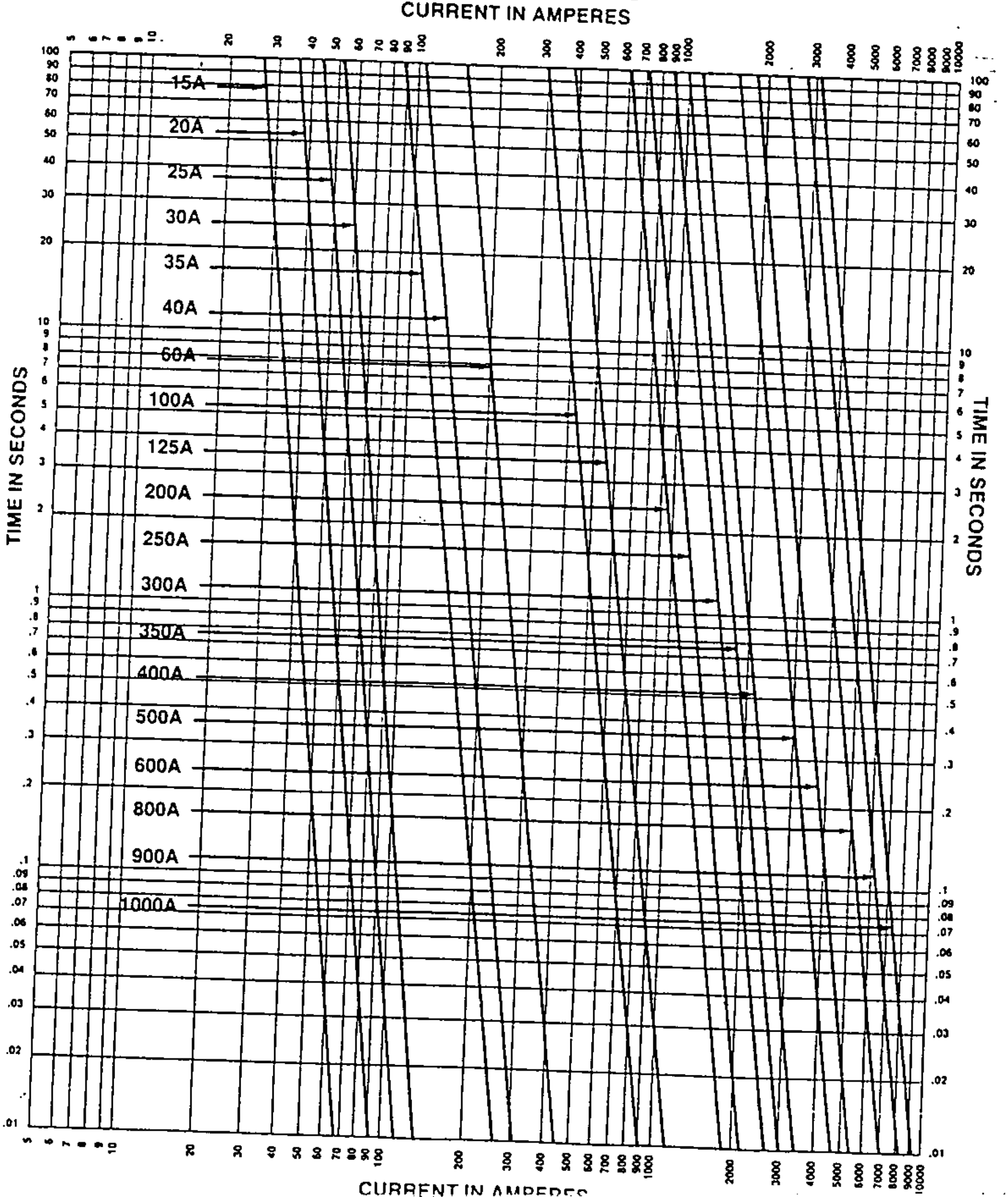
Dimensions For A100P Fuses—1000 Volts AC

FIG.	CATALOG NUMBER	MOUNTING TYPE	DIMENSIONS—INCHES A	B	C	D	E	F	G	H	J
1	A100P15-30	1	2 5/8	9/16	—	—	—	—	—	—	—
2	A100P35-60	4	5	1	3 1/2	4 5/16	4 3/16	5/16	3/4	1/8	—
2	A100P65-100	4	5	1 7/32	3 1/2	4 5/16	4 3/16	5/16	1	3/16	—
2	A100P110-200	4	5 23/32	1 1/2	3 15/32	4 25/32	4 5/32	13/32	1	1/4	—
2	A100P225-400	4	5 23/32	2	3 15/32	4 25/32	4 5/32	13/32	1 1/2	1/4	—
2	A100P450-600	4	7 23/32	2 1/2	3 15/32	5 7/8	5 9/16	17/32	2	3/8	—
3	A100P650-800	4	7 7/16	2 7/8	3 15/16	5 15/16	—	5/8	2	3/8	5/16
4	A100P850-1000	4	8 7/32	3 1/2	4 15/32	6 19/32	5 27/32	5/8	2 3/4	1/2	1 3/8

Amp-trap®–Form 101
Semiconductor Fuses

A100P

Melting Time—Current Data—A100P Fuses
15-2000 Amperes, 1000 Volts AC/DC

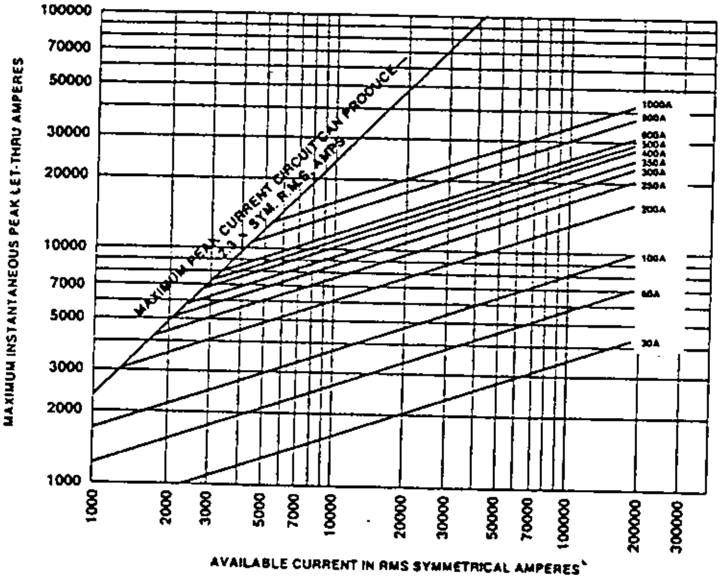


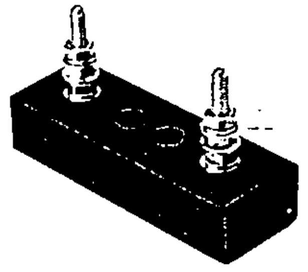
Amp-trap®–Form 101

Semiconductor Fuses

A100P

Peak Let-Thru Current Data
A100P Fuses
30-1000 Amperes, 1000 Volts AC





Single Pole Fuse Blocks⁺ For A100P Fuses

FUSE AMPERE RATING	FUSE BLOCK CATALOG NUMBER
35-100	P266G
125-400	P266L

⁺Dimensions are shown on page 111.

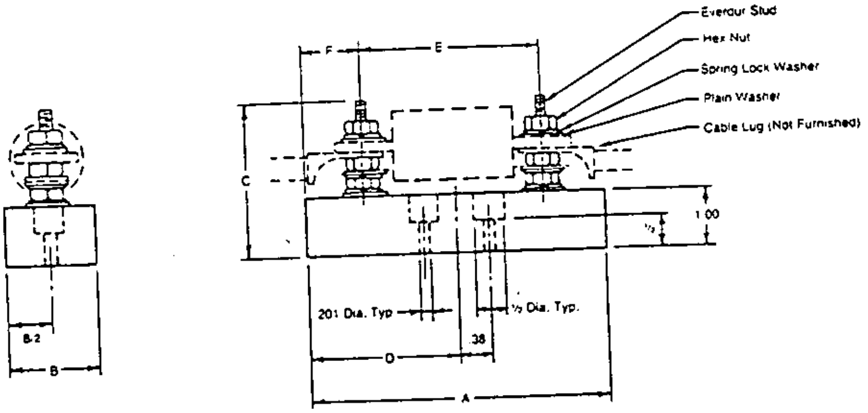
Standard Fuse Ampere Ratings* For A100P Fuses

AMPERE RATING	MOUNTING TYPE	AMPERE RATING	MOUNTING TYPE	AMPERE RATING	MOUNTING TYPE
15	1	70	4, 4TI	350	4, 4TI
20	1	80	4, 4TI	400	4, 4TI
25	1	100	4, 4TI	500	4, 4TI
30	1	125	4, 4TI	600	4, 4TI
35	4	150	4, 4TI	650	4
40	4	200	4, 4TI	700	4
50	4, 4TI	225	4	800	4, 4TI
60	4, 4TI	250	4, 4TI	1,000	4
65	4	300	4, 4TI		

*Includes standard ampere ratings and the mounting types available in each ampere rating.

Amp-trap®—Form 101
Fuse Blocks
A13X/A25X/A50P
A60X/A70P/A70Q/A100P

Dimensions:



Fuse Block Dimensions—For Type 4 Form 101 Amp-trap® Fuses

VOLTS	AMPERES	CATALOG NUMBER	FOR USE WITH	DIMENSIONS—INCHES						STUD SIZE
				A	B	C	D	E	F	
130	70-450	P243D	A13X, A13Z	4½	1½	2½	2¼	2¹⁄₁₆	1⁷⁄₃₂	¼-20
	500-600	P243G	A13X, A13Z	4½	1½	2½	2¼	2⁷⁄₁₆	1⁷⁄₃₂	⁵⁄₁₆-18
250	35-60	P243G	A25X, A25Z	4½	1½	2½	2¼	2⁷⁄₁₆	1¹⁄₃₂	⁵⁄₁₆-18
	70-200	P243	A25X, A25Z	4½	1½	2½	2¼	2⅜	1¹⁄₁₆	¼-20
	225-600	P243G	A25X, A25Z	4½	1½	2½	2¼	2⁷⁄₁₆	1¹⁄₃₂	⁵⁄₁₆-18
500	35-60	P243G	A50P	4½	1½	2½	2¼	2⁷⁄₁₆	1¹⁄₃₂	⁵⁄₁₆-18
	70-200	P243E	A50P	4½	1½	2½	2¼	2⅞	¹³⁄₁₆	¼-20
	225-600	P266C	A50P	6	2	3	3	3⁹⁄₃₂	1²³⁄₆₄	⅜-16
600	35-200	P243C	A60X, A60Z	4½	1½	2½	2¼	3⅝	⁷⁄₁₆	¼-20
	225-600	P266A	A60X, A60Z	6	2	3	3	4¹⁄₁₆	³¹⁄₃₂	⅜-16
700	35-100	P243C	A70P, A70Q	4½	1½	2½	2¼	3⅝	⁷⁄₁₆	¼-20
	125-400	P266A	A70P, A70Q	6	2	3	3	4¹⁄₁₆	³¹⁄₃₂	⅜-16
	450-600	P266F	A70P, A70Q	8	2½	3	4	5³⁄₃₂	1²⁹⁄₆₄	⅜-16
1000	35-100	P266G	A100P	6	2	2½	3	4¼	⅞	¼-20
	125-400	P266L	A100P	6	2	3	3	4²¹⁄₃₂	⁴³⁄₆₄	⅜-16

ORIES

uffix TA) is
ses. This
fuse
ed on the
ation. The
sed to
d with logic
ol action.

om the
ng or
e effect on
pere or
Actuator will
s to the
oil
(dep uing
ss an open

on extends from
ger Actuator
n fuse opens.

ngle pole
es resistive,
imum. Two
available.
type terminals
with push-on

og Number AOS-S
og Number AOS-O

DRAWING REFERENCE LIST

4482-A2 - DRAWING REFERENCE LIST
4482-D3 - CATHODE BREAKER ELEMENTARY
4482-D4 - TRACK FEEDER BREAKER ELEMENTARY
4482-D5 - GAP AND STORAGE TRACK FEEDER ELEMENTARY
4482-D6 - COMMON CIRCUITS ELEMENTARY
4482-D7 - ANCHORING DETAIL
4482-D11 - ELEVATION AND SECTIONS VIEWS - WINDHAM LANE SUBSTATION

4482-D12 - ELEVATION AND SECTION VIEWS - LANSDOWNE WAY SUBSTATION

4482-D13 - ELEVATION AND SECTION VIEWS - U-STREET SUBSTATION

4482-D14 - ELEVATION AND SECTION VIEWS - MOUNT VERNON SQUARE SUBSTATION

4482-D15 - ELEVATION AND SECTION VIEWS - MOUNT VERNON SQUARE TIE BREAKER STATION

4482-D16 - ELEVATION AND SECTION VIEWS - NOYES LANE TIE BREAKER STATION

4482-D17 - ELEVATION AND SECTION VIEWS - HILDAROSE DRIVE TIE BREAKER STATION

4482-D18 - ELEVATION AND SECTION VIEWS - WHEATON TIE BREAKER STATION

4482-D19 - ELEVATION AND SECTION VIEWS - SHAW TIE BREAKER STATION

4482-D21 - POWER DIAGRAM - WINDHAM LANE SUBSTATION
4482-D22 - POWER DIAGRAM - LANSDOWNE WAY SUBSTATION
4482-D23 - POWER DIAGRAM - U-STREET SUBSTATION
4482-D24 - POWER DIAGRAM - MOUNT VERNON SQUARE SUBSTATION

4482-D25 - POWER DIAGRAM - MOUNT VERNON SQUARE TIE BREAKER STATION

4482-D26 - POWER DIAGRAM - NOYES LANE TIE BREAKER STATION

4482-D27 - POWER DIAGRAM - HILDAROSE DRIVE TIE BREAKER STATION

4482-D28 - POWER DIAGRAM -- WHEATON TIE BREAKER STATION

wf:BN6

MICRO FILMED

DRAWN BY
BN
-5-89
SCALE
CHK'D
APP'D DL

CONTROLLED POWER LIMITED PARTNERSHIP
1501 RAFF RD SW
CANTON, OHIO 44710

TITLE DRAWING REFERENCE LIST

1	SIL	11/2/89	Removed A1 - Does not exist
NO	BY	DATE	DESCRIPTION

REVISIONS

DWG NO 4482-A2

SHEET 1 of 3

KPF 121984

DRAWING REFERENCE LIST

4482-D29	-	POWER DIAGRAM - SHAW TIE BREAKER STATION
4482-D31	-	UNIT INTERCONNECTIONS - WINDHAM LANE SUBSTATION
4482-D32	-	UNIT INTERCONNECTIONS - LANSDOWNE WAY SUBSTATION
4482-D33	-	UNIT INTERCONNECTIONS - U-STREET SUBSTATION
4482-D34	-	UNIT INTERCONNECTIONS - MOUNT VERNON SQUARE SUBSTATION
4482-D35	-	UNIT INTERCONNECTIONS - MOUNT VERNON SQUARE TIE BREAKER STATION
4482-D36	-	UNIT INTERCONNECTIONS - NOYES LANE TIE BREAKER STATION
4482-D37	-	UNIT INTERCONNECTIONS - HILDAROSE DRIVE TIE BREAKER STATION
4482-D38	-	UNIT INTERCONNECTIONS - WHEATON TIE BREAKER STATION
4482-D39	-	UNIT INTERCONNECTIONS - SHAW TIE BREAKER STATION
4482-D41	-	CONNECTION DIAGRAM - CATHODE BREAKER WITH CURRENT TRANSDUCER
4482-D42	-	CONNECTION DIAGRAM - CATHODE BREAKER WITH CURRENT, VOLTAGE AND WATT TRANSDUCER
4482-D43	-	CONNECTION DIAGRAM - 4000A TRACK FEEDER
4482-D44	-	CONNECTION DIAGRAM - GAP OR STORAGE TRACK FEEDER
4482-D45	-	CONNECTION DIAGRAM - TRACK FEEDER WITH AUXILIARY CIRCUITS
4482-D46	-	CONNECTION DIAGRAM - 6000A TRACK FEEDER
4482-D47	-	EQUIPMENT INTERCONNECTIONS - NOYES LANE TIE BREAKER STATION
4482-D48	-	EQUIPMENT INTERCONNECTIONS - HILDAROSE DRIVE TIE BREAKER STATION

wf:BN6

MICRO FILMED

DRAWN BY BN
9-5-89
SCALE
CHK'D
APP'D BCN

CONTROLLED POWER LIMITED PARTNERSHIP
1501 RAFF RD. SW.
CANTON, OHIO 44710

NO	BY	DATE	DESCRIPTION

REVISIONS

TITLE DRAWING REFERENCE LIST
DWG. NO. 4482-A2
SHEET 2 of 3

DRAWING REFERENCE LIST

4482-D49 - EQUIPMENT INTERCONNECTONS -
MOUNT VERNON SQUARE TIE BREAKER STATION

4482-D50 - EQUIPMENT INTERCONNECTIONS -
WHEATON TIE BREAKER STATION

4482-D51 - EQUIPMENT INTERCONNECTIONS -
SHAW TIE BREAKER STATION

4482-C108 - REAR VIEW - WINDHAM LANE SUBSTATION
4482-C109 - REAR VIEW - LANSDOWNE WAY SUBSTATION
4482-C110 - REAR VIEW - U-STREET SUBSTATION
4482-C111 - REAR VIEW - MOUNT VERNON SQUARE SUBSTATION

4482-C112 - REAR VUEW - MOUNT VERNON SQUARE
TIE BREAKER STATION

4482-C113 - REAR VIEW - NOYES LANE TIE BREAKER STATION
4482-C114 - REAR VIEW - HILDAROSE DRIVE TIE BREAKER STATION
4482-C115 - REAR VIEW - WHEATON TIE BREAKER STATION
4482-C116 - REAR VIEW - SHAW TIE BREAKER STATION

4482-D164 - EQUIPMENT INERCONNECTIONS -
LANSDOWNE WAY SUBSTATION

4482-D165 - EQUIPMENT INTERCONNECTIONS -
WINDHAM LANE SUBSTATION

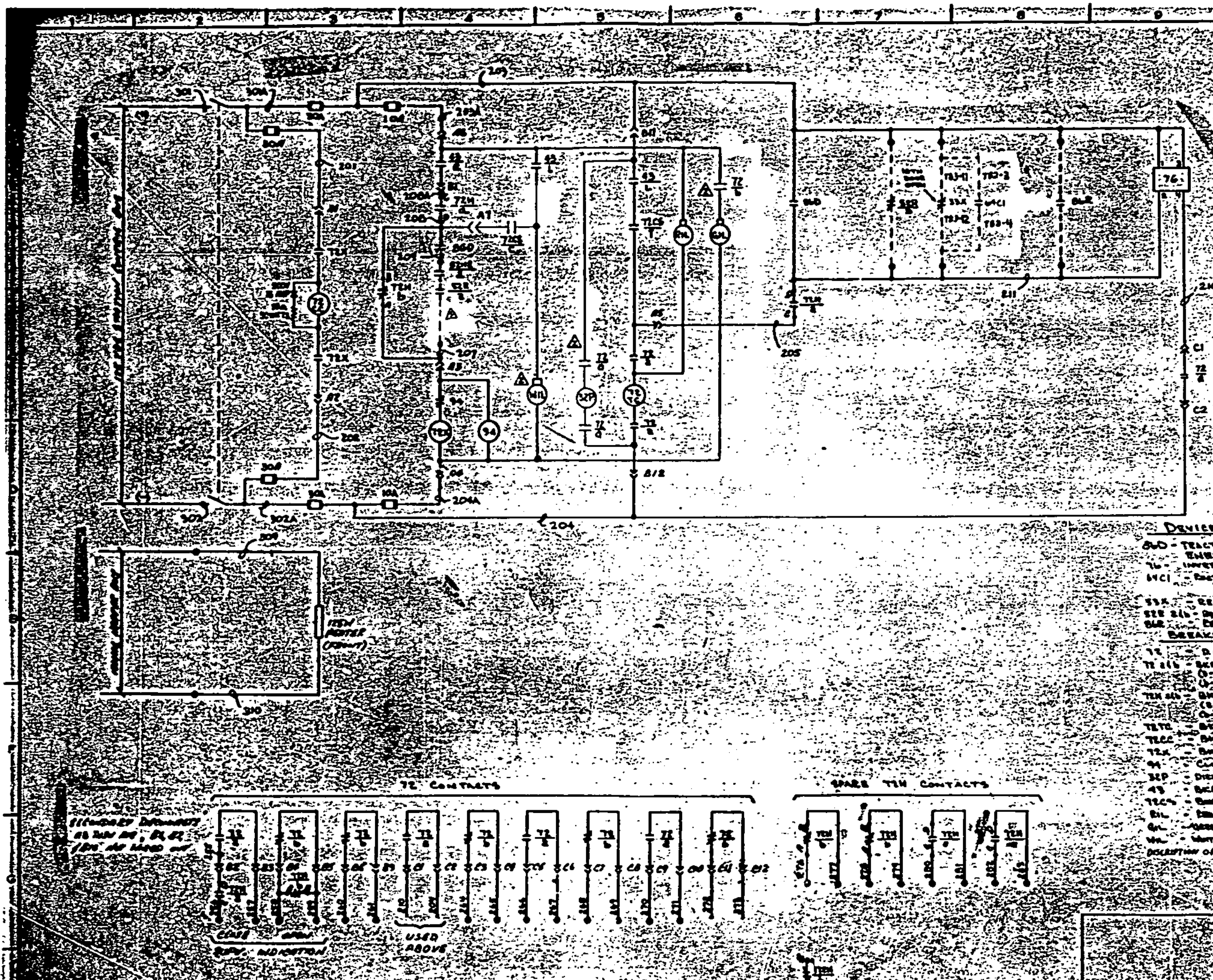
4482-D166 - EQUIPMENT INTERCONNECTIONS -
MOUNT VERNON SQUARE SUBSTATION

4482-D167 - EQUIPMENT INTERCONNECTIONS - U-STREET SUBSTATION
4482-A51 - DESCRIPTION OF OPERATION - CATHODE BREAKERS
4482-A52 - DESCRIPTION OF OPERATION - TRACK FEEDER BREAKERS

wf:BN6

MICRO FILMED 4 1990

DRAWN BY BN	**CONTROLLED POWER LIMITED PARTNERSHIP** 1501 RAFF RD. SW. CANTON, OHIO 44710					
DATE 9-5-89						
SCALE		NO	BY	DATE	DESCRIPTION	
CHK'D.		REVISIONS				
APP'D. BCN	TITLE DRAWING REFERENCE LIST	DWG. NO. 4482-A2		SHEET 3 of 3		



DEVICE LEGEND

8UD - TRACTION STATION STRUCTURE ENERGIZED LOCKOUT RELAY
76 - INVERSE TRIPPING RELAY
64C1 - RECT. STRUCTURE HOT or GROUNDED

33A - RECT. DOOR SW.
52E a/b - RECT. FOR BKR. AUX. CONTACTS
8UR - RECT. FOR LOCKOUT RELAY

BREAKER LEGEND

72 - D.C. CATHODE BKR
72 a/b - BKR. AUX. CONTACTS
(a - OPEN WHEN BKR IS OPEN)
(b - CLOSED WHEN BKR IS OPEN)
72H a/b - BKR. TRUCK POSITION SWITCH
(a - OPEN IN THE TEST AND DISCONNECT POS.)
(b - CLOSED IN THE TEST AND DISCONNECT POS.)
72TC - BKR. TRIP COIL
72CC - BKR. CLOSE COIL
72X - BKR. CLOSING RELAY
94 - CLOSING COIL ANTI-PUMP RELAY
32P - DIRECT ACTING REVERSE CURRENT TRIP
43 - BKR. REMOTE/LOCAL SELECTOR SW.
72CS - BKR. CONTROL SWITCH
RIL - RED IND. LT. (BKR. CLOSED)
GIL - GREEN IND. LT. (BKR. OPEN)
WIL - WHITE IND. LT. (LOCAL CONTROL)
DESCRIPTION OF OPERATION SEE DWG. 4483-A51

STAGE	43		
	CONTACTS	REMOTE	LOCAL
1	1 - 2	X	
	3 - 4		X
2	1 - 2	X	
	3 - 4		X
3	1 - 2	X	
	3 - 4		X
4	1 - 2	X	
	3 - 4		X

STAGE	72CS			
	CONTACTS	CLOSE	NORM	TRIP
1	1 - 2	X		
	3 - 4			X
2	1 - 2	X		
	3 - 4			X

JFK
5-21-88
AB

[redacted]

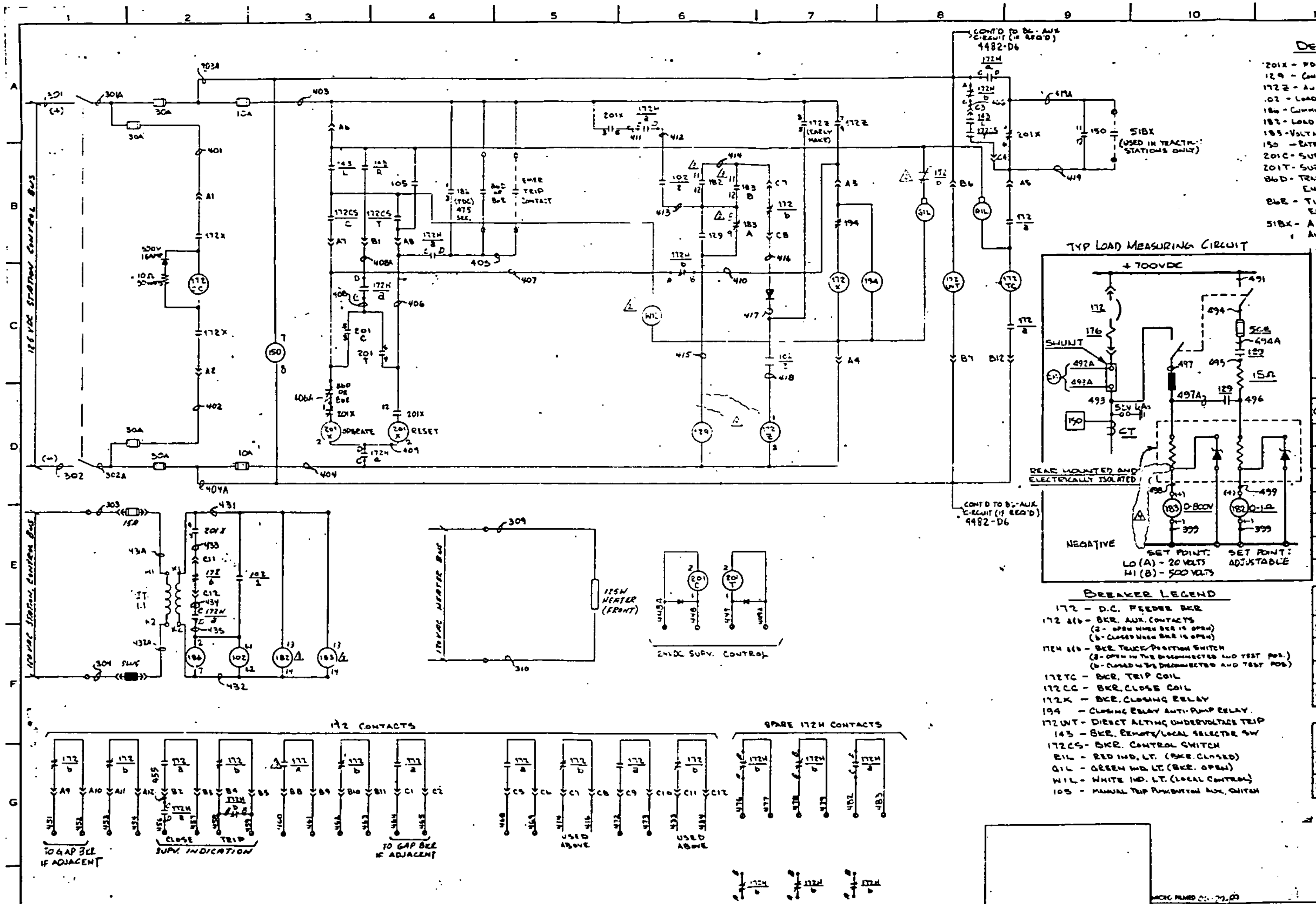
WMATA / SS-9
CONTRACT 121049
KINGSTON CONTRACTORS

CATHODE BREAKER
ELEMENTARY

4482-D3

3

MAY 24 1990



DEVICE LEGEND

- 201X - FDR. MASTER RELAY (LATCHING)
- 129 - CONTACTOR FOR LOAD MEASURING RESISTOR
- 172Z - AUXILIARY CLOSING RELAY
- .02 - LOAD MEASURING CKT. TIMING RELAY
- 186 - CUMMULATIVE LOCK-OUT TIMING RELAY (30-300 SEC)
- 182 - LOAD MEASURING RELAY
- 183 - VOLTAGE MEASURING TRANSFER RELAY
- 150 - RATE OF RISE OVERCURRENT RELAY
- 201C - SUPERVISORY CLOSE RELAY
- 201T - SUPERVISORY TRIP RELAY
- 86D - TRACTION STATION STRUCTURE ENERGIZED LOCK-OUT RELAY
- 86E - TIE STATION STRUCTURE ENERGIZED LOCK-OUT RELAY
- 51BX - A.C. SWITCHGEAR RECT. FDR. AUX. RELAY TO DEVICE 51B

DESCRIPTION & SEQUENCE OF OPERATION SEE DWG. 4453-A52

IT - ISOLATION TRANSFORMER (SEV

BREAKER LEGEND

- 172 - D.C. FEEDER BKR
- 172 a/b - BKR. AUX. CONTACTS
  - (a - OPEN WHEN BKR IS OPEN)
  - (b - CLOSED WHEN BKR IS OPEN)
- 172H a/b - BKR TRUCK/POSITION SWITCH
  - (a - OPEN IN THE DISCONNECTED AND TEST POS.)
  - (b - CLOSED IN THE DISCONNECTED AND TEST POS)
- 172TC - BKR. TRIP COIL
- 172CC - BKR. CLOSE COIL
- 172K - BKR. CLOSING RELAY
- 194 - CLOSING RELAY ANTI-PUMP RELAY.
- 172UVT - DIRECT ACTING UNDERVOLTAGE TRIP
- 143 - BKR. REMOTE/LOCAL SELECTOR SW
- 172CS - BKR. CONTROL SWITCH
- R1L - RED IND. LT. (BKR. CLOSED)
- G1L - GREEN IND. LT. (BKR. OPEN)
- W1L - WHITE IND. LT. (LOCAL CONTROL)
- 105 - MANUAL TRIP PUSHBUTTON AUX. SWITCH

102 (15 SEC PER REV.)	
CONTACT	TIME (SECONDS) 0 5 10 15
102/1	1.0 CLOSED
102/2	4.0 6.0
102/3	5.5 11.5
102/4	
102/5	
102/6	

STAGE	143		
	CONTACTS	REMOTE	LOCAL
1	1 - 2	X	
	3 - 4		X
2	1 - 2	X	
	3 - 4		X
3	1 - 2	X	
	3 - 4		X
4	1 - 2	X	
	3 - 4		X

STAGE	172CS ✱			
	CONTACTS	CLOSE	NORM	TRIP
1	1 - 2	X		
	3 - 4			X
2	1 - 2	X		
	3 - 4			X

✱ - SPRING RETURN TO NORMAL

NO	BY	DATE	APP	REVISIONS
1	JHS	8-29-88	AB	CUST. REV'S
2	PJ	9-21-88		ENG'G REV'S
3	JHS	11-27-88		MNTR CHANGE
4	JHS	1-29-89		ENG'G REV'S

MICRO FILMED 06-22-89

DRAWN BY JFK
DATE 5-20-88
CHECKED AB

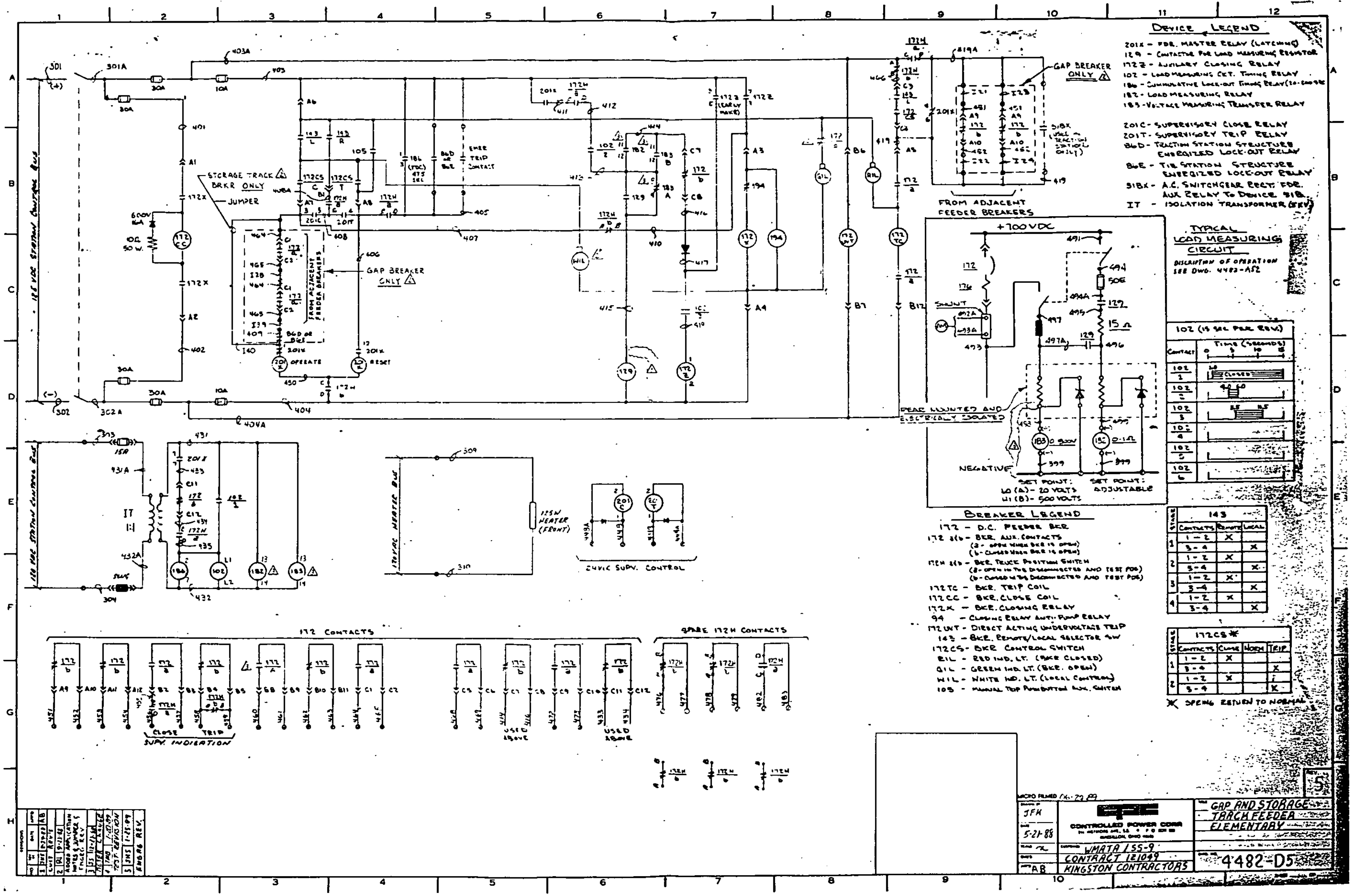
CPC
CONTROLLED POWER CORP.

WMATA / SS-9
CONTRACT 1B1049
KINGSTON CONTRACTORS

TRACK FEEDER
ELEMENTARY

DWG. NO. 4482-D4

MAY 24 1990



DEVICE LEGEND

201X – FDR. MASTER RELAY (LATCHING)
129 – CONTACTOR FOR LOAD MEASURING RESISTOR
172Z – AUXILIARY CLOSING RELAY
102 – LOAD MEASURING CKT. TIMING RELAY
186 – CUMMULATIVE LOCK-OUT TIMING RELAY (20-ENDS?)
182 – LOAD MEASURING RELAY
183 – VOLTAGE MEASURING TRANSFER RELAY

201C – SUPERVISORY CLOSE RELAY
201T – SUPERVISORY TRIP RELAY
86D – TRACTION STATION STRUCTURE ENERGIZED LOCK-OUT RELAY
86E – TIE STATION STRUCTURE ENERGIZED LOCK-OUT RELAY
518X – A.C. SWITCHGEAR RECT. FDR. AUX RELAY TO DEVICE 51B.
IT – ISOLATION TRANSFORMER (5KV)

TYPICAL LOAD MEASURING CIRCUIT

DISCRIPTION OF OPERATION SEE DWG. 4482-A52

BREAKER LEGEND

172 – D.C. FEEDER BKR
172 a/b – BKR AUX. CONTACTS
(a – OPEN WHEN BKR IS OPEN)
(b – CLOSED WHEN BKR IS OPEN)
172H a/b – BKR. TRUCK POSITION SWITCH
(a – OPEN IN THE DISCONNECTED AND TEST POS)
(b – CLOSED IN THE DISCONNECTED AND TEST POS)
172TC – BKR. TRIP COIL
172CC – BKR. CLOSE COIL
172X – BKR. CLOSING RELAY
94 – CLOSING RELAY ANTI-PUMP RELAY
172UVT – DIRECT ACTING UNDERVOLTAGE TRIP
143 – BKR. REMOTE/LOCAL SELECTOR SW
172CS – BKR CONTROL SWITCH
RIL – RED IND. LT. (BKR CLOSED)
GIL – GREEN IND. LT. (BKR. OPEN)
WIL – WHITE IND. LT. (LOCAL CONTROL)
105 – MANUAL TRIP PUSHBUTTON AUX. SWITCH

STAGE	143		
	CONTACTS	REMOTE	LOCAL
1	1 – 2	X	
	3 – 4		X
2	1 – 2	X	
	3 – 4		X
3	1 – 2	X	
	3 – 4		X
4	1 – 2	X	
	3 – 4		X

STAGE	172CS ✱			
	CONTACTS	CLOSE	NORM	TRIP
1	1 – 2	X		
	3 – 4			X
2	1 – 2	X		
	3 – 4			X

✱ SPRING RETURN TO NORMAL

NO	BY	DATE	APPD	REVISIONS
1	DHF	8-29-88	AB	CUST REV'S
2	RL	9-23-88		ADDED APPLICATION NOTES & JUMPER & ENGR'G. REV
3	SS	12-12-88		METER CHANGE
4	TMD	1-20-89		POST REVISION
5	SNS	1-25-89		ENGR'G REV.

MICRO FILMED 06-22-89

JFK
5-21-88
AB

CONTROLLED POWER CORP

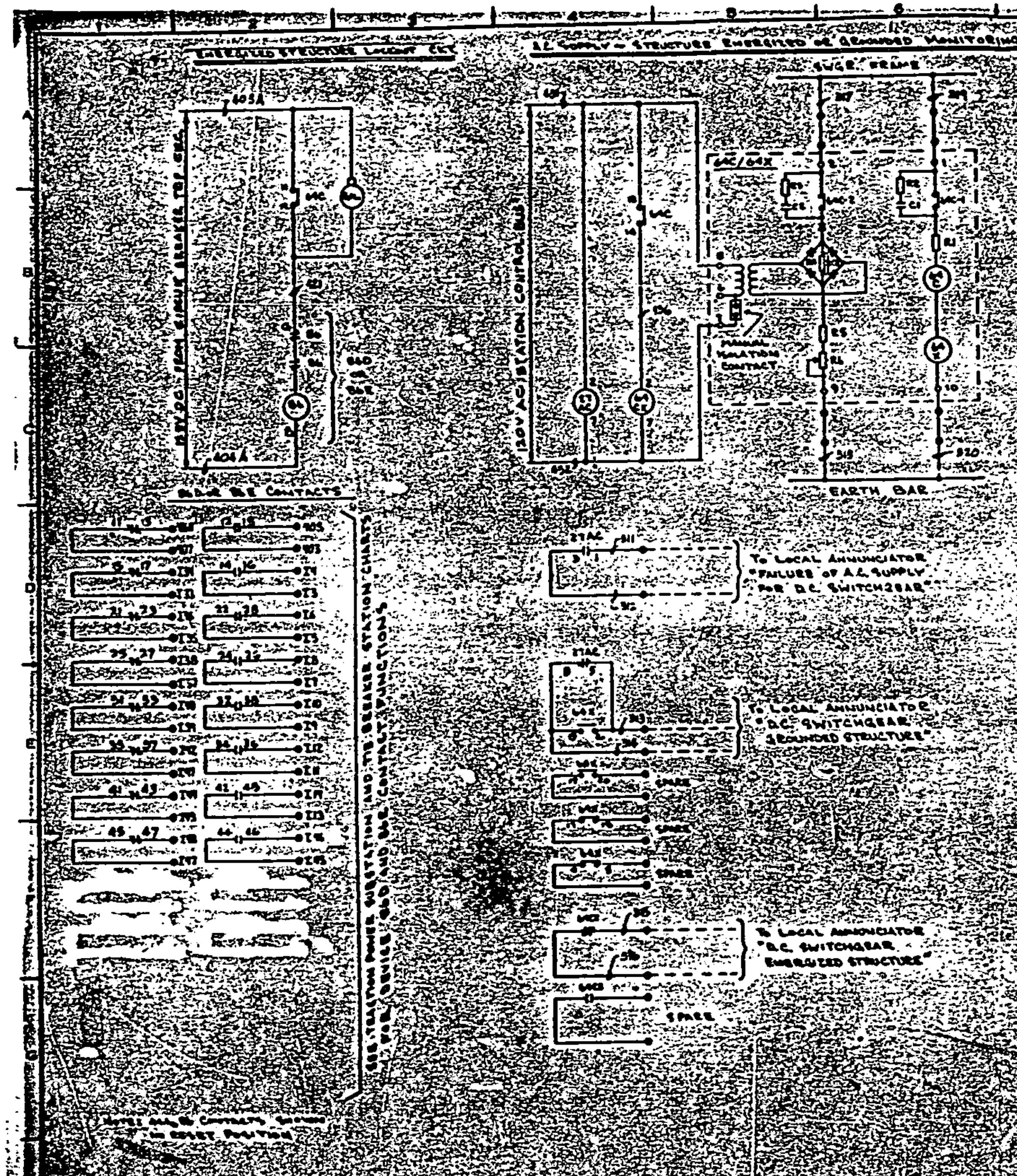
WMATA / SS-9
CONTRACT 121049
KINGSTON CONTRACTORS

GAP AND STORAGE TRACK FEEDER ELEMENTARY

4482-D5

REV. 5

MAY 24 1990



TRACTION POWER SUBSTATION CHART FOR DEVICE 86D FUNCTIONS

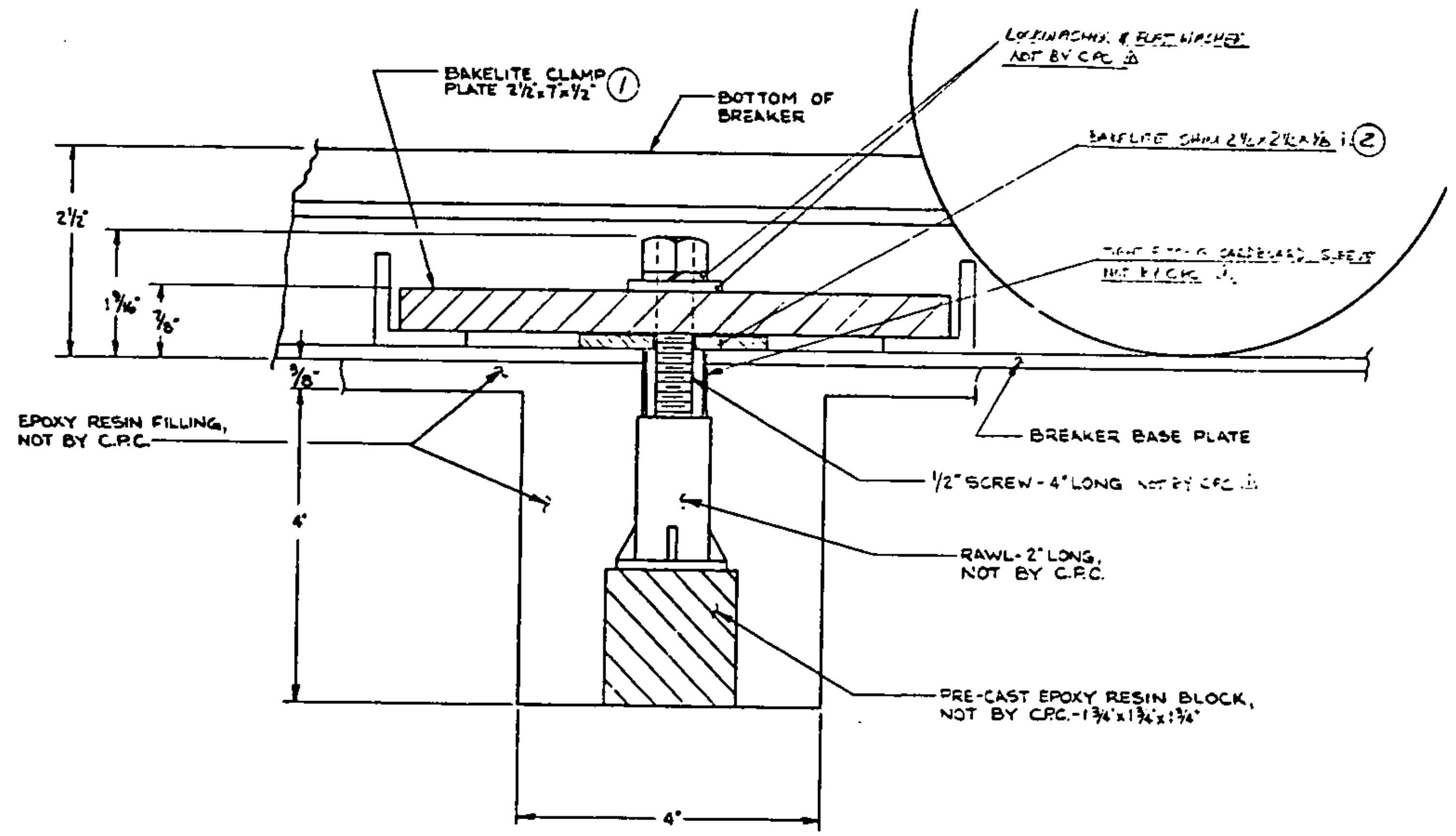
TRACTION POWER SUBSTATIONS	11-13	15-17	21-23	25-27	31-33	35-37	41-43	45-47					
	12-18	14-16	22-28	24-26	32-38	34-36	42-48	44-46					
WINDHAM LANE	172-3	172-2	172-1	172-4	72-1	72-2							
LANSDOWNE WAY	172-4	172-2	172-3	172-1	72-1	72-2							
U STREET	172-3	172-2	172-1	172-4	172-5	72-1	72-2						
MOUNT VERNON SQUARE	172-2	172-1	172-3	172-4	172-5	172-6	72-1	72-2					

TIE BREAKER STATION CHART FOR DEVICE 86E FUNCTIONS

TIE BREAKER STATIONS	11-13	15-17	21-23	25-27	31-33	35-37	41-43	45-47					
	12-18	14-16	22-28	24-26	32-38	34-36	42-48	44-46					
NOYES LANE	172-1	172-2	172-3	172-4									
HILDAROSE	172-1	172-2	172-3	172-4									
WHEATON	172-4	172-2	172-3	172-1	172-5								
SHAW	172-1	172-2	172-3	172-4	172-5								
MOUNT VERNON SQUARE	172-2	172-1	172-3	172-4	172-5								

3

JFK
5-20-88
[redacted]
CONTROLLED POWER CORP
WMATA/ISS-9
CONTRACT 1B1049
HINGSTON CONTRACTORS
COMMON CIRCUITS
ELEMENTARY
4482-D6



NOTE: QUANTITY LISTED IN B/M IS PER CELL

2	2	SHIM	4482-A135
1	2	CLAMP PLATE	3796-A135
ITEM	QTY	DESCRIPTION	DWG NO

BILL OF MATERIAL

REV. 1

MICRO FILMED 7-29-88

C

PAB

5/23/88

N.T.S.

CONTROLLED POWER CORP

NIGATA, SS-9

CONTRACT # 121049

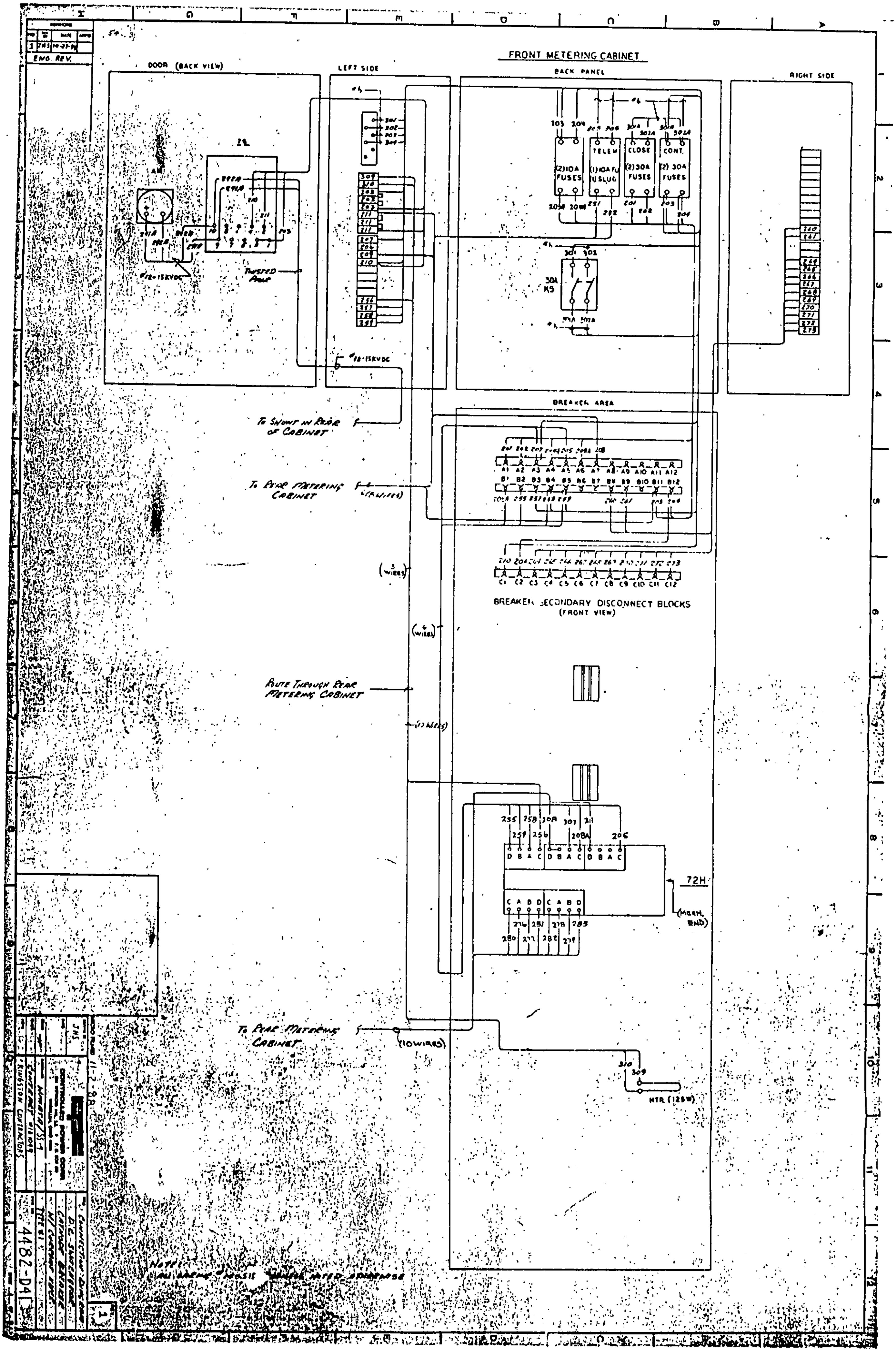
KINGSTON CONTRACTORS

TYPICAL ASSEMBLY OF BREAKER ANCHOR PROVISIONS

4482-D7

MAY 2 4 1990

D



11-2-88

JHS

CONTROLLED POWER CORP

WMATA/SS-1

CONTRACT #1B1099

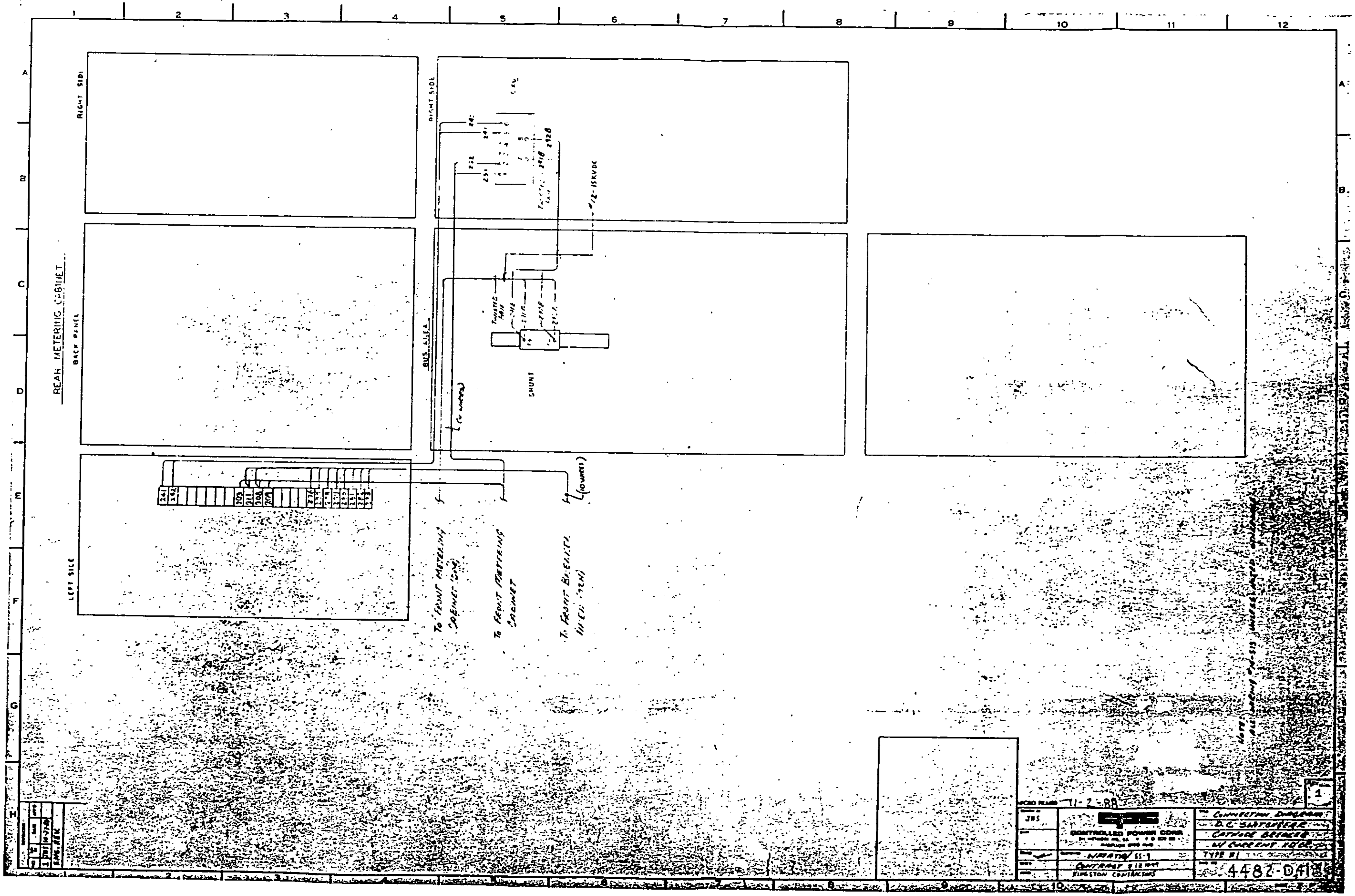
KINGSTON CONTRACTORS

CONNECTION DIAGRAM
D.C. SWITCHGEAR
CATHODE BREAKER
W/ CURRENT LOCK

TYPE #1

4482-D41

MAY 2 4 1990



11-2-88

JHS

CONTROLLED POWER CORP.

NMATA/SS-1

CONTRACT 812

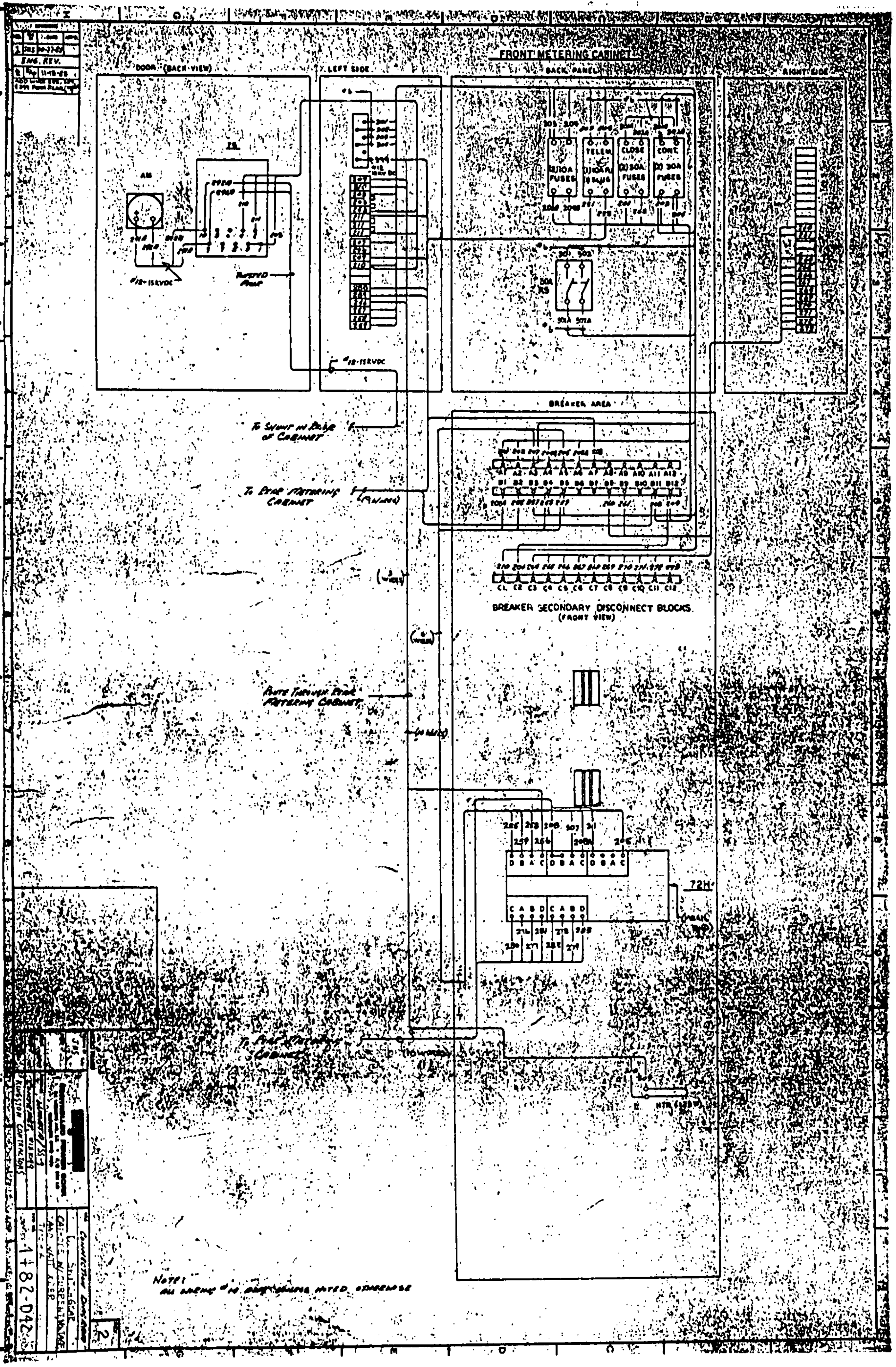
KINGSTON CONTRACTORS

CONNECTION DIAGRAM
D.C. SWITCHGEAR
CATHODE BREAKER
W/ CURRENT LOOP
TYPE #1

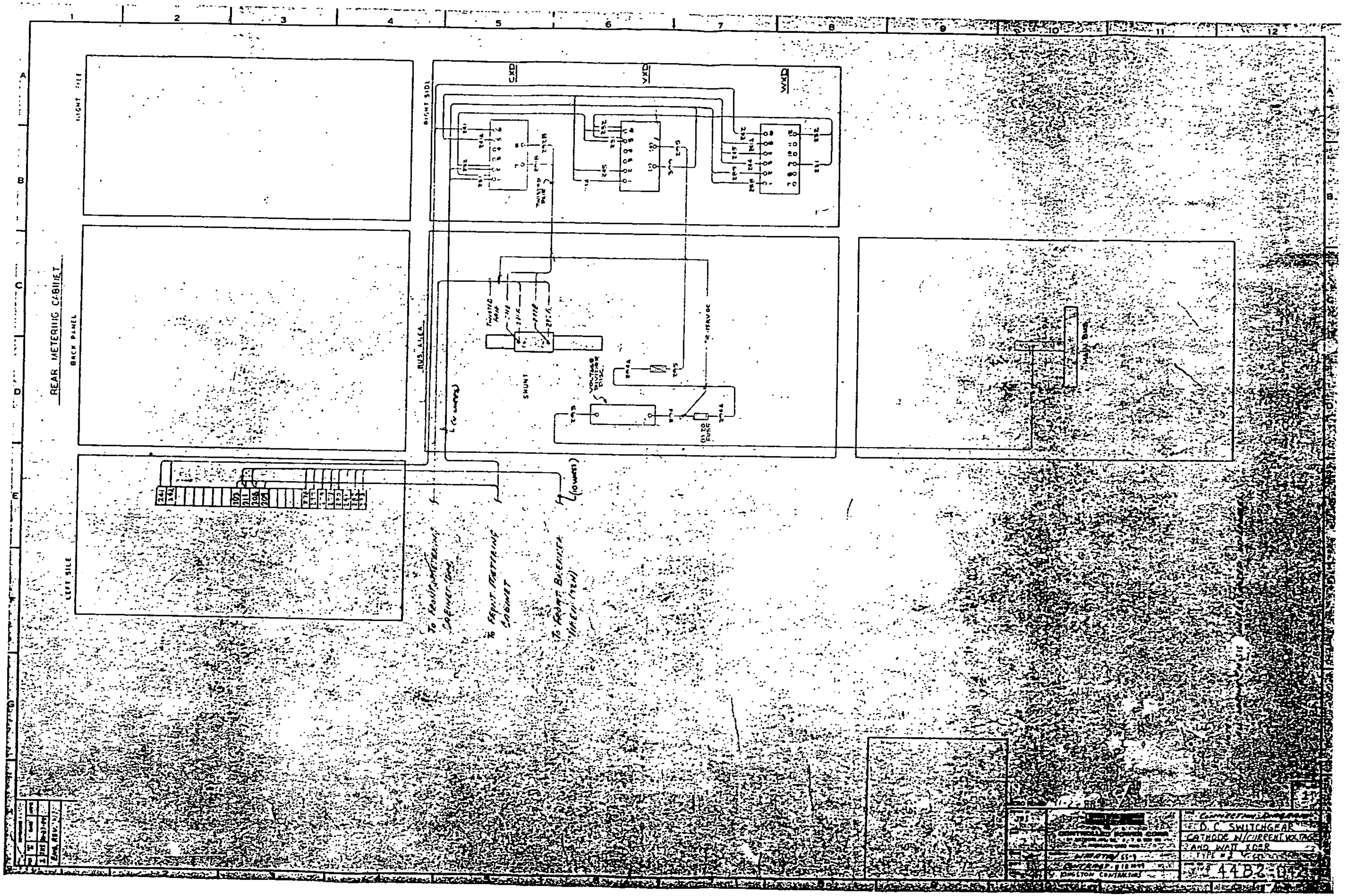
4482-D41

1

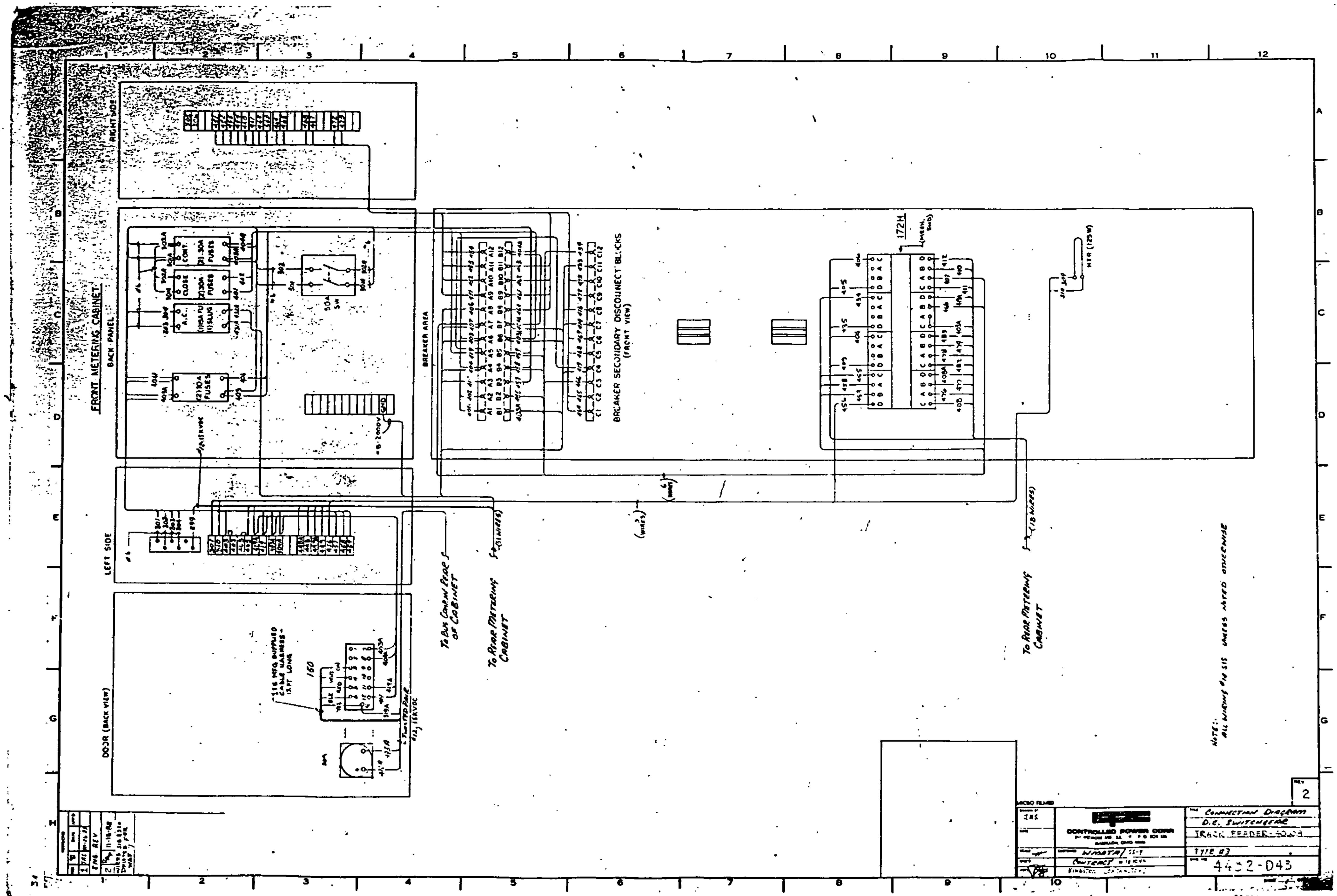
MAY 24 1990


FRONT METERING CABINET
DOOR (BACK VIEW)
LEFT SIDE
BACK PANEL
RIGHT SIDE
AM
7S
TWISTED PAIR
#18-15KVDC
(1) 10A FUSES
TELEM (1) 10A/15 SLUG
CLOSE (2) 30A FUSES
CONT (2) 30A FUSES
30A RS
BREAKER AREA
A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12
B1 B2 B3 B4 B5 B6 B7 B8 B9 B10 B11 B12
C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12
BREAKER SECONDARY DISCONNECT BLOCKS
(FRONT VIEW)
72H
D B A C D B A C D B A C
C A B D C A B D
To SHUNT IN BASE OF CABINET
To REAR METERING CABINET
(9 WIRES)
(3 WIRES)
(6 WIRES)
ROUTE THROUGH REAR METERING CABINET
(10 WIRES)
To REAR METERING CABINET
MTR SHUNT
NOTE 1
ALL WIRING #14 UNLESS NOTED OTHERWISE
ENG. REV.
JBS
[redacted]
KINGSTON CONTRACTORS
CONNECTION DIAGRAM
CABINET W/ CURRENT, VOLTAGE AND WATT METER
1-82-042
2

MAY 24 1990


REAR METERING CABINET
BACK PANEL
RIGHT SIDE
LEFT SIDE
BUS AREA
CXD
VXD
WXD
TWISTED PAIR
SHUNT
VOLTAGE DIVIDER DISC.
MAIN BUS
L (UPPER)
(LOWER)
To FRONT METERING CABINET (OLD)
To FRONT METERING CABINET
To FRONT BREAKER (UPPER) (NEW)
CONTROLLED POWER CORP.
CONNECTION DIAGRAM
D.C. SWITCHGEAR
CATHODE W/CURRENT, VOLTAGE
AND WATT XDCR
TYPE #3
44B2-042

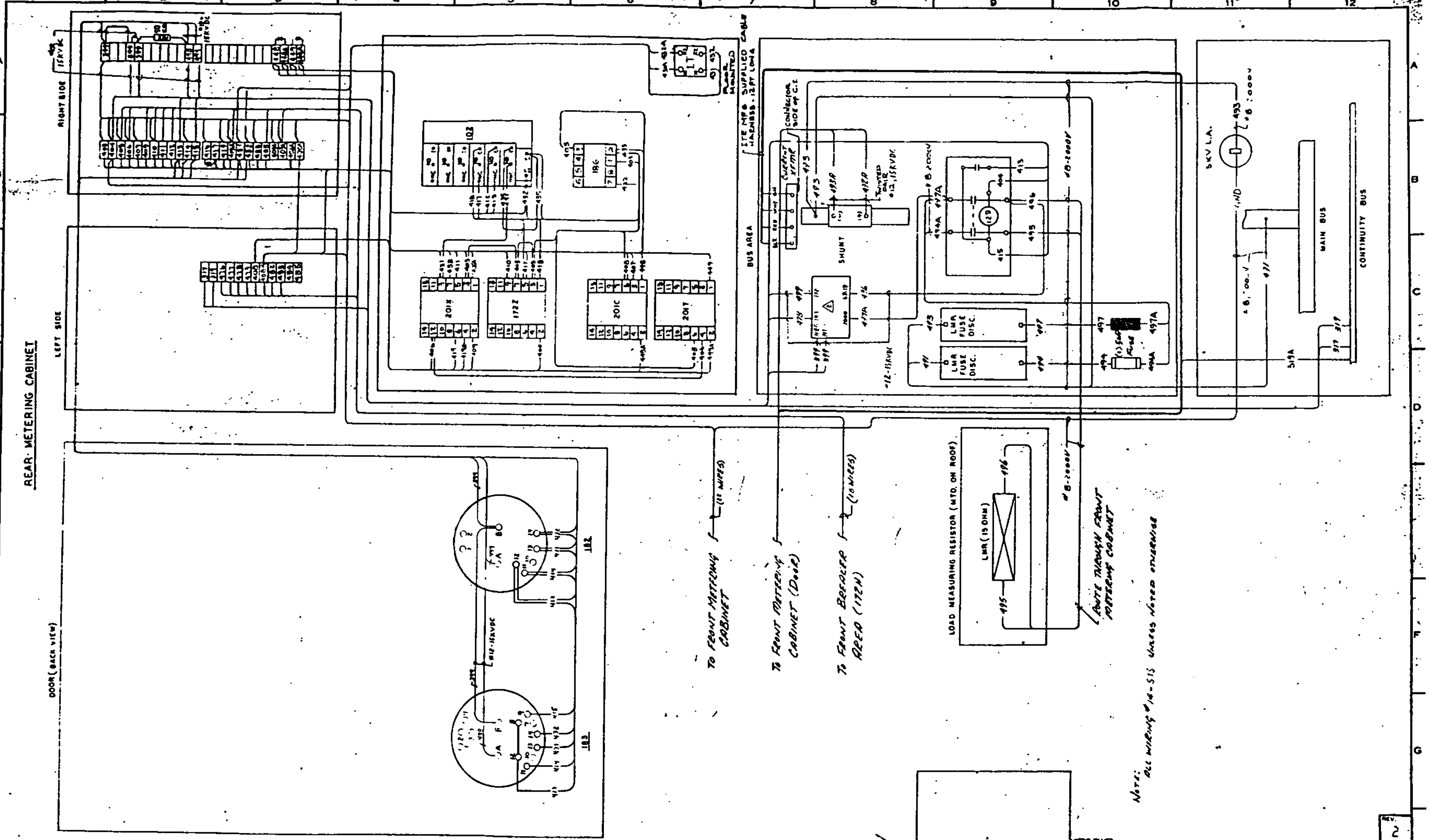
MAY 2 4 1990



CONTROLLED POWER CORP

Connection Diagram
D.C. Switchgear
Track Feeder - 40-A9
Type #3
WMATA / SS-7
Contract
Kingston
4432-D43

MAY 24 1990



TO FRONT METERING CABINET

TO FRONT METERING CABINET (DOOR)

TO FRONT BREAKER AREA (172N)

NOTE:
ALL WIRING #14-SIS UNLESS NOTED OTHERWISE

1	3H5	10-27-86	ENG. REV
2	3H5	12-11-86	METER CHANGE

MICRO FILMED

J-5

CONTROLLED POWER CORP

WMATA

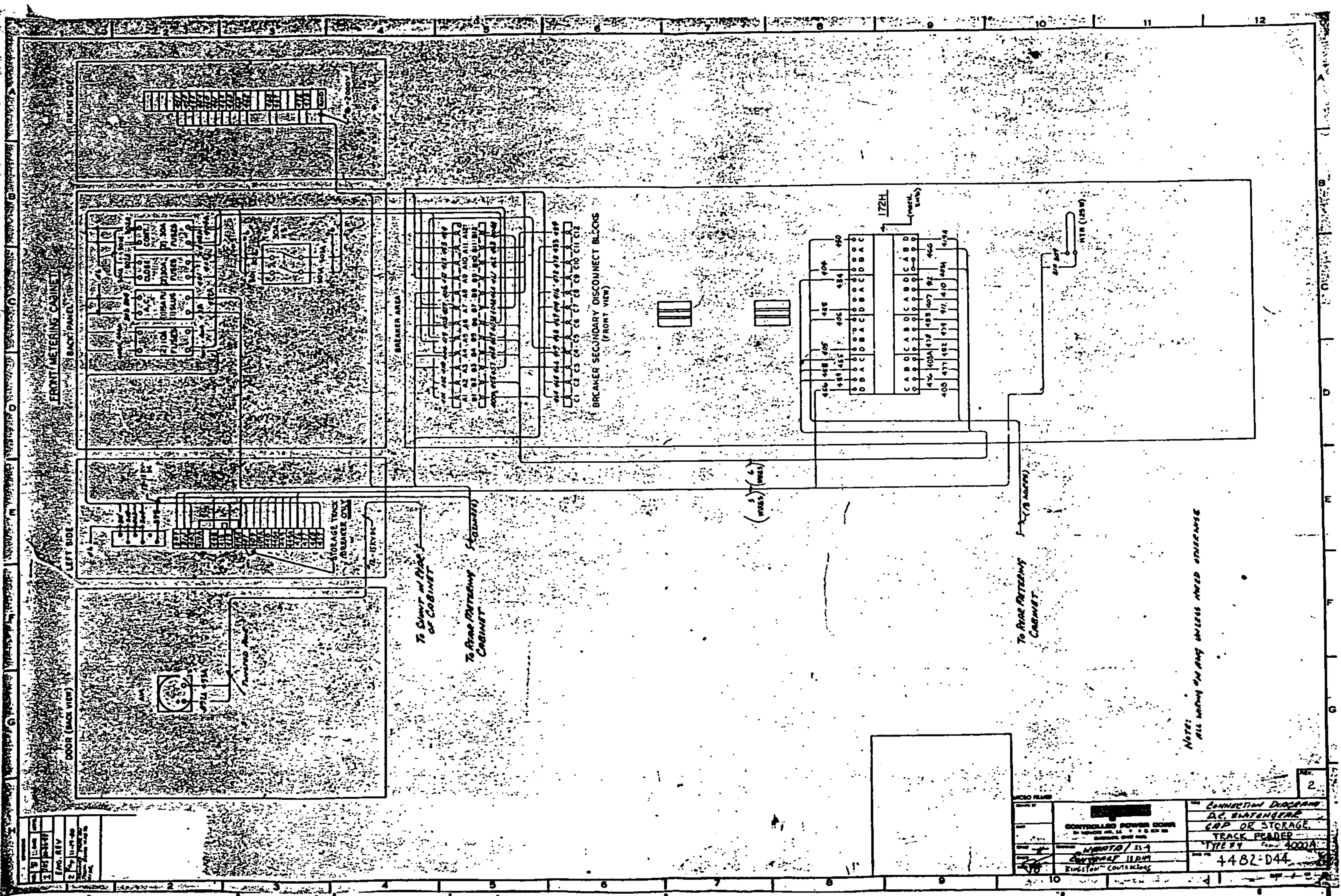
CONTRACT # 1

REV. 2

CONNECTION DIAGRAM
D.C. SWITCHGEAR
TRACK FEEDER - 4000A
TYPE #3

4452-D45

MAY 2 4 1990



CONTROLLED POWER CORP.

NIAGARA / SS-4

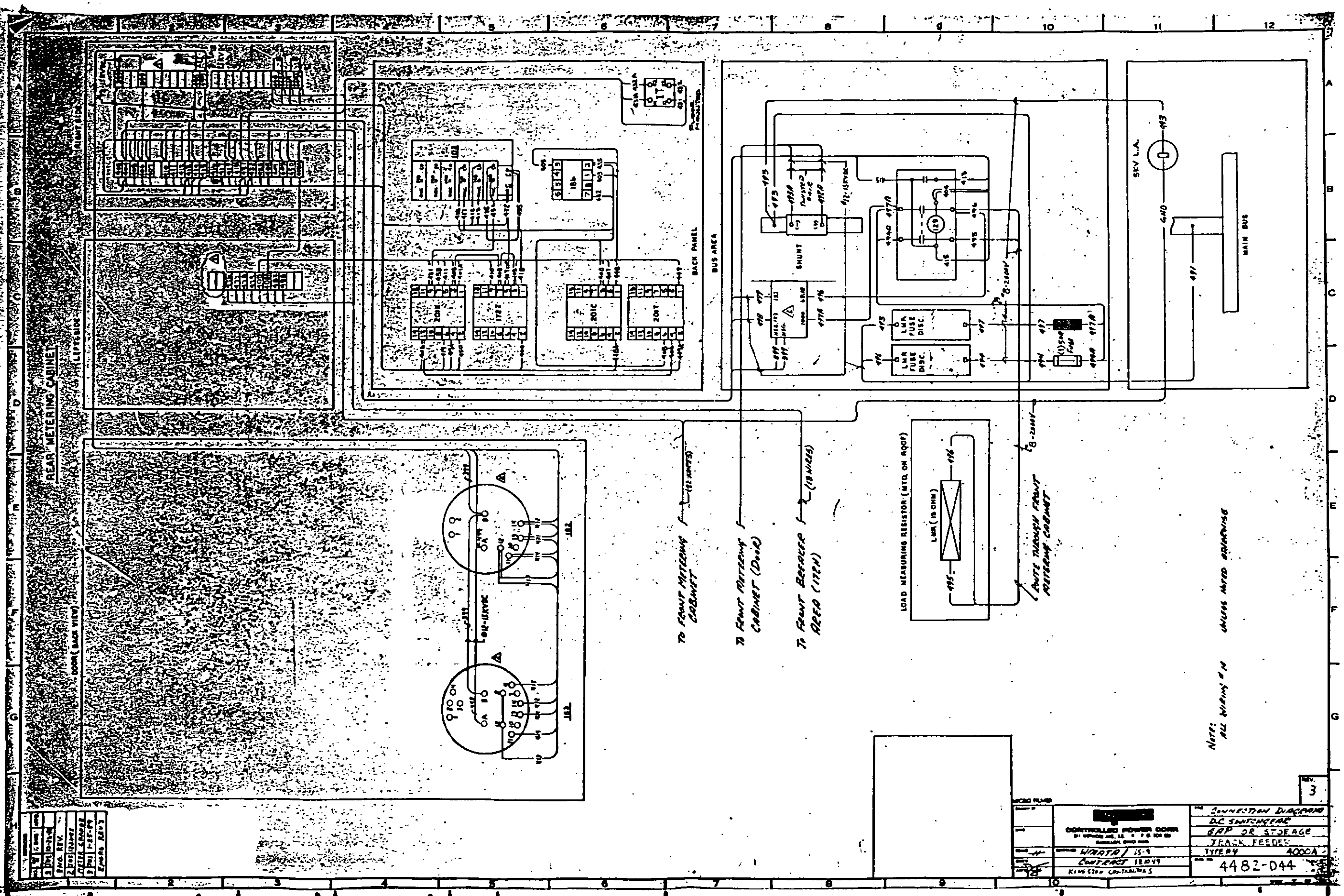
KINGSTON CONTRACTORS

CONNECTION DIAGRAM
D.C. SWITCHGEAR
GAP OR STORAGE
TRACK FEEDER
TYPE FY 4000A

4482-D44

REV. 2

MAY 2 4 1990



CONTROLLED POWER CORP

WMATA / 15-9

CONTRACT 1B1049

KINGSTON CONTRACTORS

CONNECTION DIAGRAM

DC SWITCHGEAR

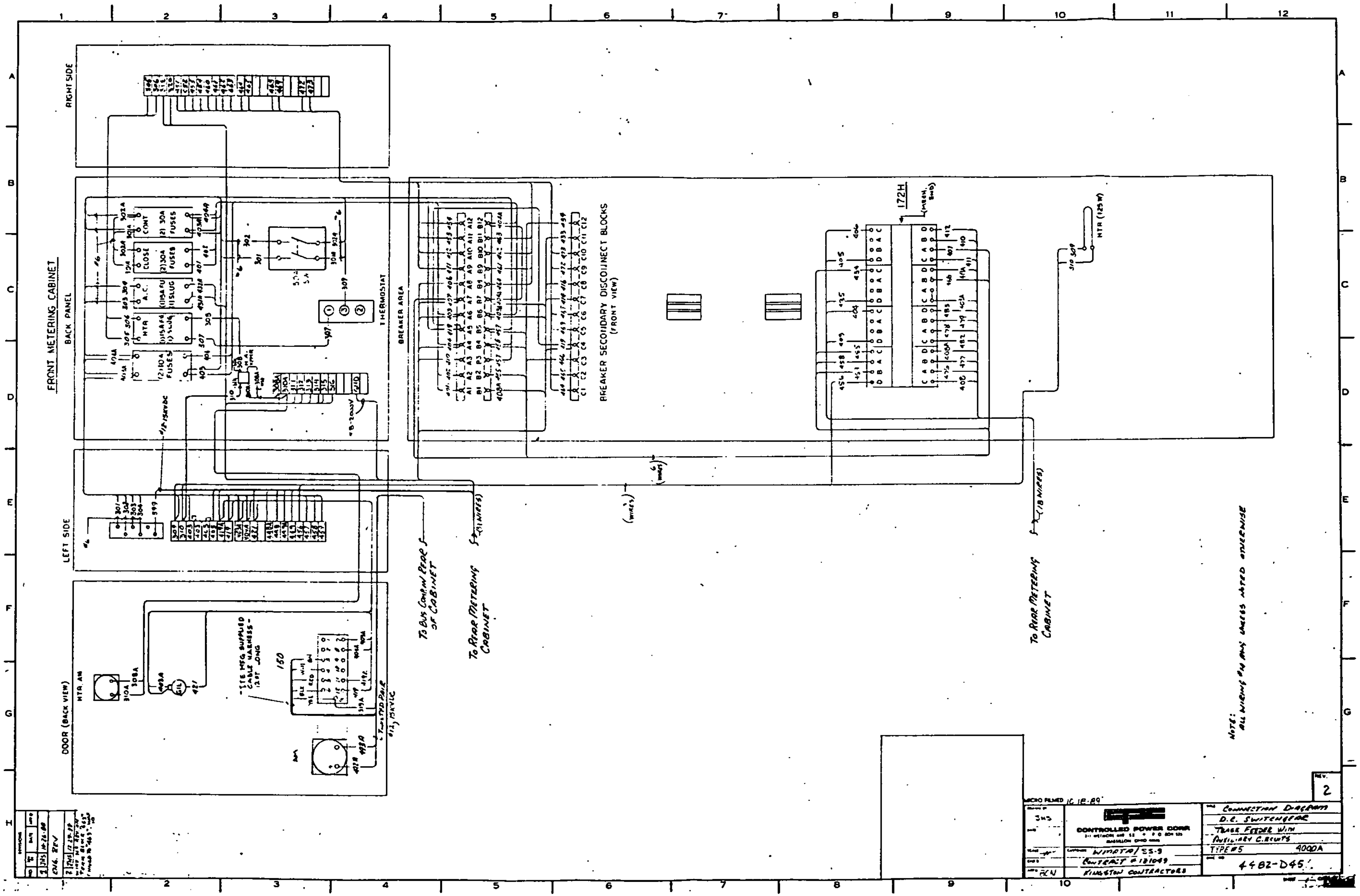
GAP OR STORAGE

TRACK FEEDER

TYPE 4Y 4000A

4482-044

MAY 24 1990



REV	BY	DATE
1	JHS	10-26-88
	ORIG. REV	
2	JHS	12-29-89

MICRO FILMED 10-18-89

REV.
2

JHS

CONTROLLED POWER CORP.

WMATA/SS-9

CONTRACT #181049

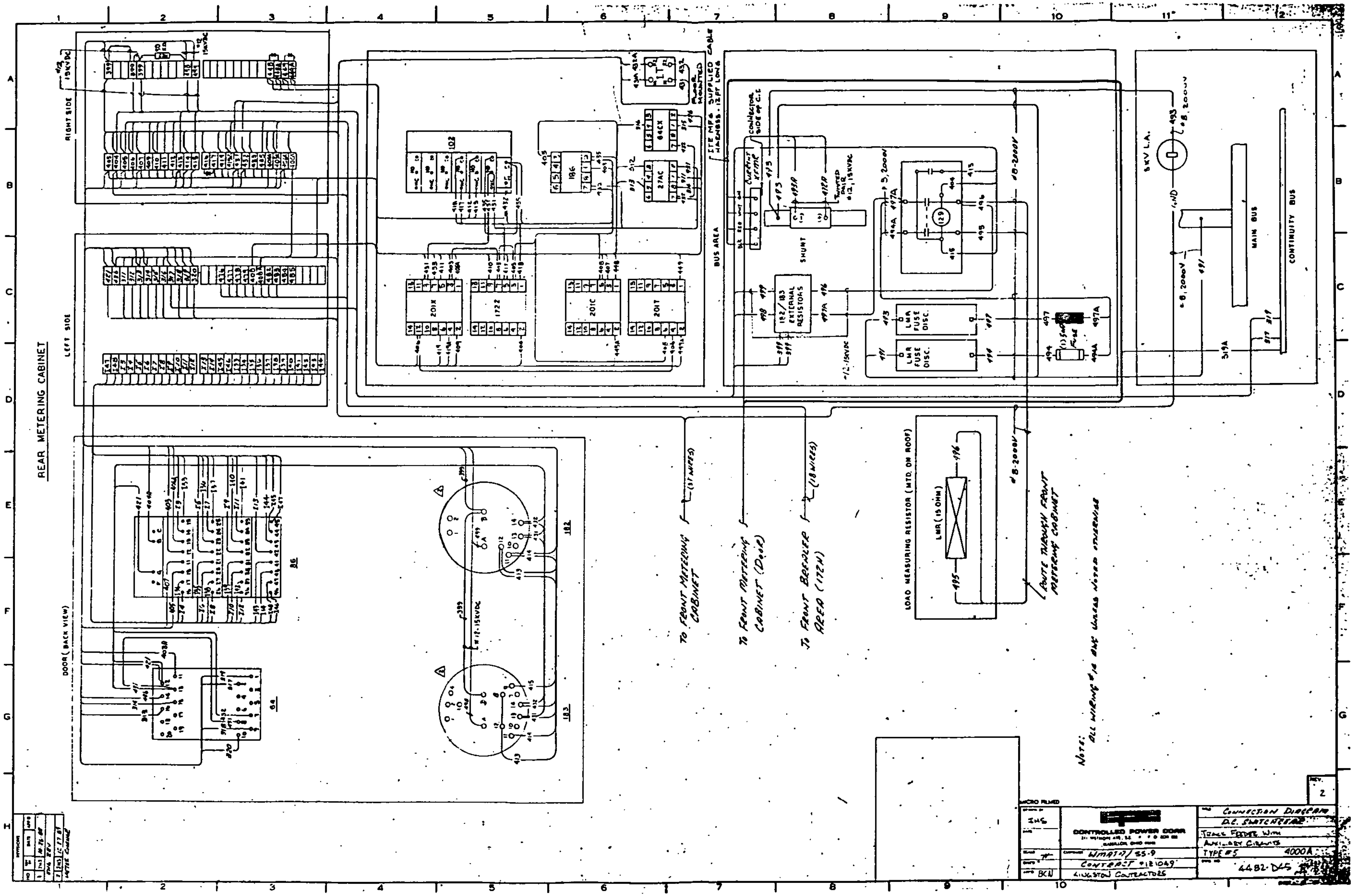
KINGSTON CONTRACTORS

RCN

CONNECTION DIAGRAM
D.C. SWITCHGEAR
TRACK FEEDER WITH
AUXILIARY CIRCUITS
TYPE #5 4000A

4482-D45

MAY 2 4 1990



MICRO FILMED

IHS

BCN

CONTROLLED POWER CORP.

WMATA/ SS-9

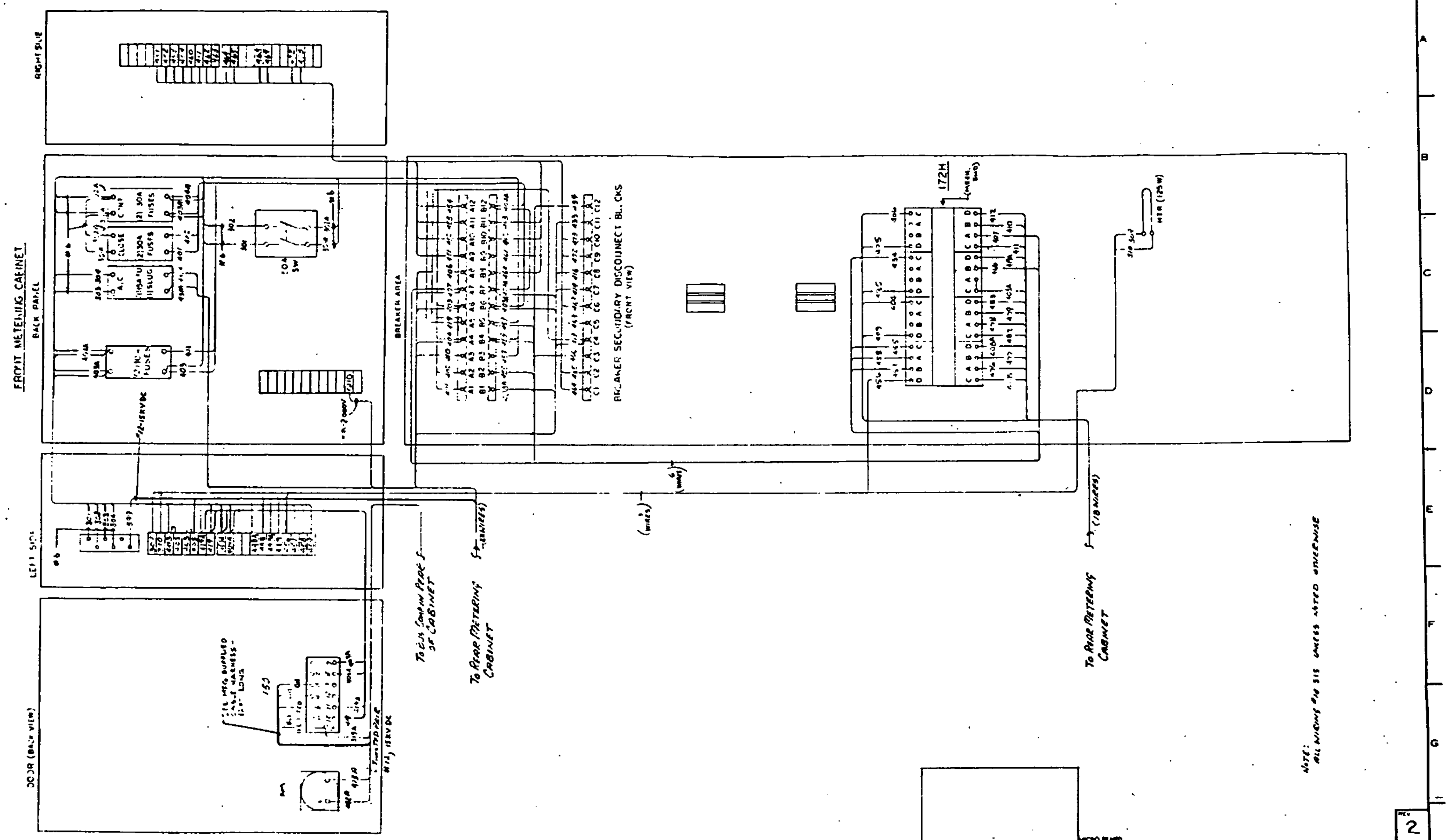
CONTRACT #1Z1049

KINGSTON CONTRACTORS

CONNECTION DIAGRAM
D.C. SWITCHGEAR
TRACK FEEDER WITH
AUXILIARY CIRCUITS
TYPE #5 4000A

4482-D45

MAY 2 4 1990



NOTE: ALL WIRING #14 SIS UNLESS NOTED OTHERWISE

1	ENG. REV
2	11-21-86

MICRO FILMED

JRS

CONTROLLED POWER CORP

WMATA/SS-1

CONTRACT

ENGSTON CONTRACTORS

CONNECTION DIAGRAM

D.C. SWITCHGEAR

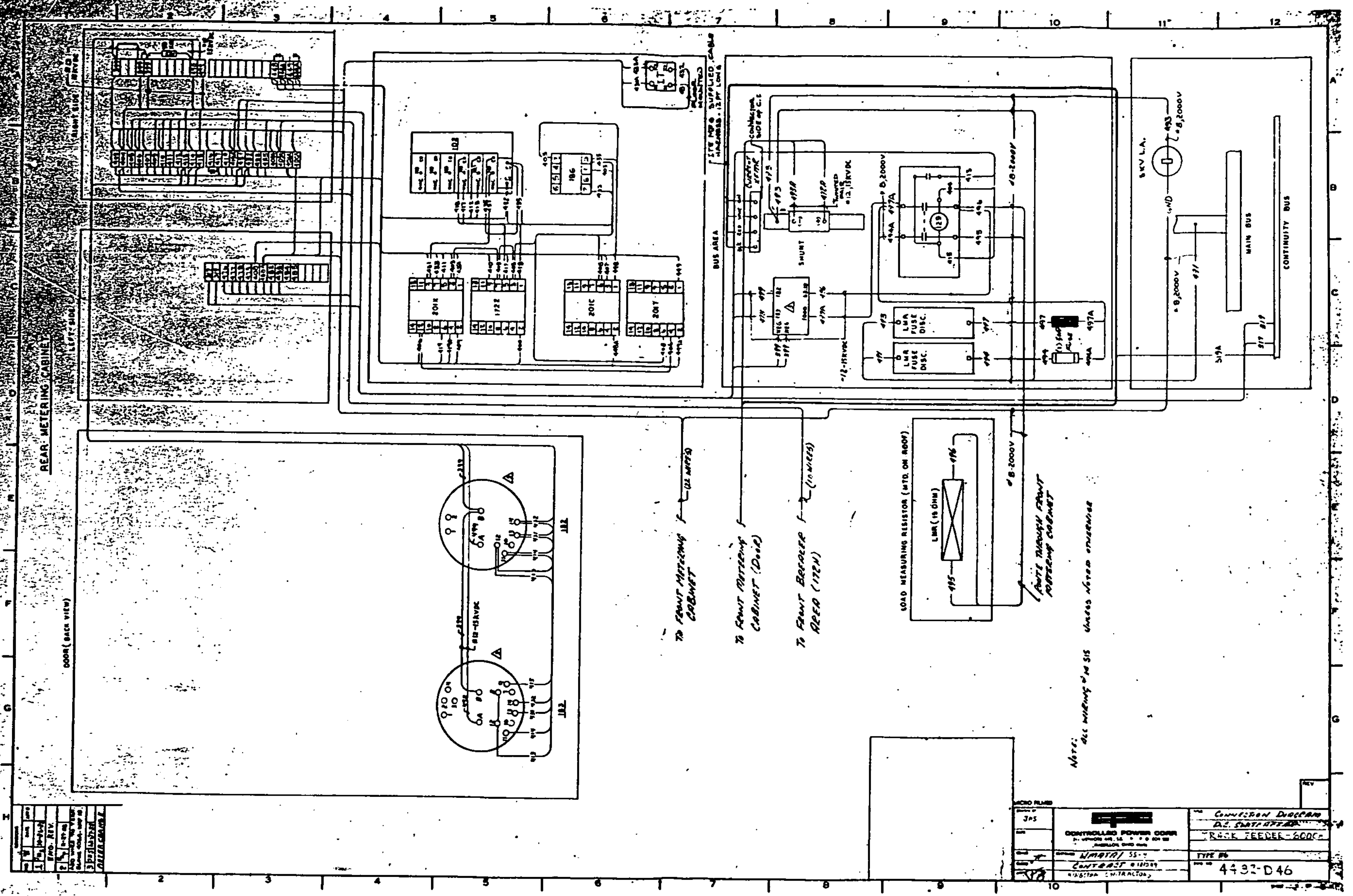
TRACK FEEDER - 6000A

TYPE 86

4‑‑62-D46

REV 2

MAY 24 1990



JPS

CONTROLLED POWER CORP

WMATA / SS-4

CONTRACT

CONNECTION DIAGRAM

D.C. SWITCHGEAR

TRACK FEEDER-6000

TYPE

4432-D46

MAY 24 1990