

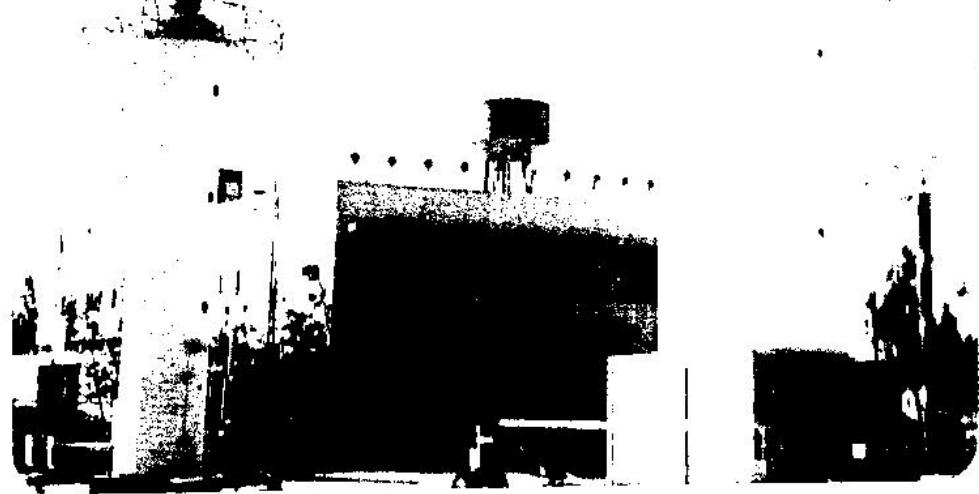
PYRAMID HIGH VOLTAGE
RESEARCH CENTRE



مركز أبحاث الجهد الفائق بالهرم

PHVRC
E.E.A. - A.R.E.

وزارة الكهرباء والطاقة
هيئة كهرباء مصر
مركز أبحاث الجهد الفائق بالهرم



التقرير الفن رقم (٤٨/٣٠)

بتاريخ ١٩٩٨/٥/٣

بخصوص

اختبار عينة كابل جهد ٣٨/٦ ك.ف. قطاع

٤٠٠ × ٤٠٠ سم ٢ نحاس عزل XLPE / ساتر معدني

وحاص غلاف خارجي بولي إيثيلين عالي الكثافة

الموقع : الكيلو ٢٧ طريق القاهرة - الإسكندرية الصحراوى .
المراسلة : هيئة كهرباء مصر - إدارة الهيئة للدراسات والبحوث والتطوير - العباسية - القاهرة .
تلبيقات : مركز أبحاث الجهد الفائق بالهرم - ت : ٢٨٢٣٥٤٦ .

الموصى
المراسلة
تلبيقات

فاكس : ٠٢٠٢ /

هيئة كهرباء مصر (الدراسات) - ت : ٢١١٦٥٢٦ / ٢١١٦٥٣٦

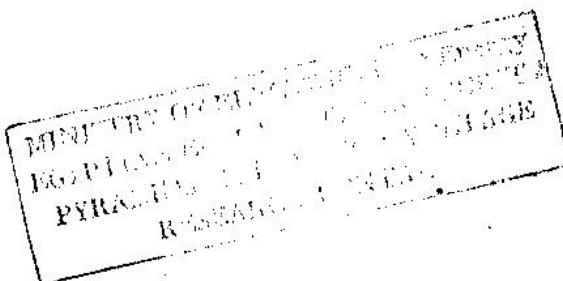
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PYRAMIDS EXTRA HIGH VOLTAGE
RESEARCH CENTER

TEST REPORT NO.(103/98)

**FOR ELECTRICAL TYPE AND
SPECIAL TESTS**

ON

***66/38 kV, 1x 400 mm² COPPER CONDUCTOR,
XLPE INSULATED, POWER CABLE WITH
COPPER SHEATH***



**CLIENT : EGYTECH CABLES (EL SEWEDY)
COMPANY.**

EGYPTIAN ELECTRICITY AUTHORITY
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TEST REPORT No :(103/98)

DATE : Oct. , 1998.

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1- CLIENT :

- EGYTECH CABLES Co.

2- DATE AND PLACE OF TESTS:

- June, July, August and Sept. 1998 in EXTRA HIGH VOLTAGE RESEARCH CENTER ,GIZA , EGYPT.
- June, August, 1998 in EGYTECH CABLES COMPANY

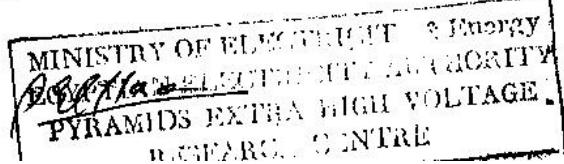
3- TEST SPECIMEN :

- 66 kV power cable , XLPE insulated , single core , copper conductor of 400 mm² with copper sheath has the following dimensions :

- Specimen length	:	20	m.
- Over all diameter	:	7.6	cm.
- Copper conductor Over all diameter	:	23.2	mm.
- No. of wires	:	55	
- Wire diameter	:	3.23	mm.
- Inner Semi-Conductor thickness	:	1.1	mm.
- XLPE Insulation thickness	:	17.34	mm.
- Outer Semi-conductor thickness	:	1.62	mm.
- H.D.P.E Thickness	:	3.5	mm.

M. Abd El Ghaffar

S. Tahour



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- IEC 885 (1988) : Electrical test methods for electric cables.
- Part 3 : Test methods for partial discharge measurements on lengths of extruded power cable.
- IEC 60 : High voltage test technique.
- IEC 71 : Insulation co-ordination.
- IEC 230 : Impulse tests on cables and their accessories

6 - TESTS SEQUENCE:

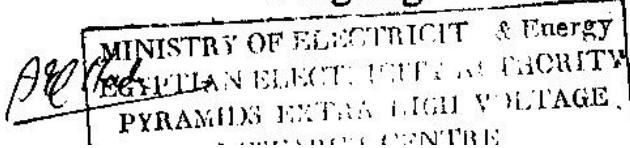
6.1) The following tests were carried out on the complete test cable specimen described above according to the test sequence in sub clause (5.5.1), IEC publication No. 840 (1988) :

- 6.1.1) Bending test followed by partial discharge test.
- 6.1.2) $\tan \delta$ measurement .
- 6.1.3) Heating cycle voltage test followed by partial discharge measurement.
- 6.1.4) Impulse withstand test followed by a power frequency voltage test.

6.2) The following tests were done on the cable components :

- 6.2.1) Hot set test.
- 6.2.2) Resistivity measurement of the semi-conductor layers before and after aging .
- 6.2.3) Tests for determining the mechanical properties of insulation before and after ageing.

M. Abd El Majeed
F. Tahaam



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7- TEST PROCEDURES AND APPARATUS:

7.1) Tests on complete cable specimen :

7.1.1) Bending test in accordance with IEC 840 clause 5.5.3 :

The sample was bent around a hub of drum at room temperature for one complete turn and then unwound. The process was repeated in the reverse direction. This cycle was carried out three times. The diameter of the hub was 250 cm. After the completion of this cycles the cable sample was subjected to the partial discharge test.

7.1.2) Partial Discharge Test in accordance with IEC 840 sub clause 5.5.4 & IEC 270 & IEC 885-2 :

- The partial discharge test was carried out as described in IEC 885-2 the sensitivity being 5 PC or less. The magnitude of discharge at $1.5 U_o$ (57 kV) shall not exceed 5 PC.
- The test was carried out in the manufacturer laboratory
- The test results met the requirements where the partial discharge was 1.5 PC.

7.1.3) $\tan \delta$ measurement in accordance with IEC 840 subclause (5.5.5):

- This test was carried out on another sample from the test cable specimen and it was heated by passing an A.C current through the conductor . The temperature of the conductor was measured by a thermo - couple

M. Abd El Ghany
S. Taha

P.D. Abd El Ghany
MINISTRY OF ELECTRICITY & ENERGY
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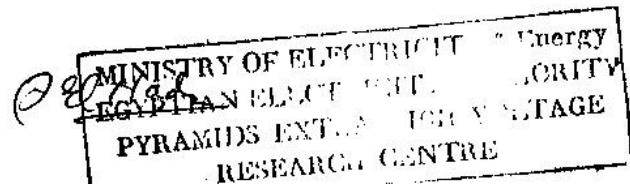
The sample was heated until the conductor reached 95°C. $\tan \delta$ was measured at a power frequency voltage of 38 kV. The measurement was carried out in the Extra High Voltage Research Center using Schering bridge type Tetex model No:(2805).

- The measured value of $\tan \delta$ is 7.5×10^{-4} which met the requirement Of IEC No : 840.

**7.1.4) Heating Cycle Test in accordance with IEC 840
Subclause (5.5.5) :**

- The sample in a U-bend shape was heated to a temperature of 97°C by passing an A.C induced current which produced by the flux of a transformer core which excited by 100 Volts from a regulating transformer 380 / 0-500 Volt, 120 kVA.
- The test circuit was described in Figure (2).
- The heating was applied for 8 hours followed by 16 hours of natural cooling.
- The conductor temperature was maintained within the above mentioned temperature for the last 2 hours of each current loading period . Figure (3) shows the temperature rise for the specimen.
- The cycle of heating and cooling was carried out 20 times. During the heating cycle test,an A.C voltage of 76 kV was applied to the sample.

M. Abd Elaziz
F. Tahoun



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- The A.C voltage was obtained from a set up transformer unit **500 kVA ,100 kV.**

This unit is equipped with :

- Regulator transformer : **380 / 0-525 Volts.**
- Control unit model : **WP 500 / 100.**
- Peak value voltmeter model : **MU 16.**

Figure(4) shows the A.C. source schematic diagram.

7.1.5 Partial Discharge measurement after the heating cycle :

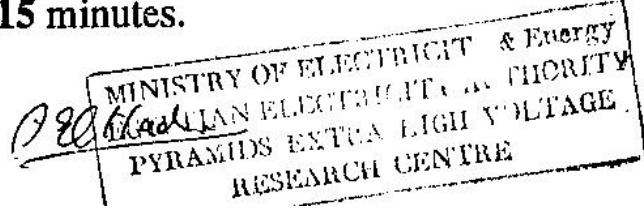
- The partial discharge was measured at **1.5 U_o(57 kV)**on the cable specimen after heating cycle at the manufacturer laboratory in witness of Extra High Voltage Research Center representatives.

- The partial discharge value was **2.2 PC.**

7.1.6 Impulse Voltage Test followed by A.C. Voltage Test :

- The impulse test was performed on the samples at a temperature of **95° C**.The impulse voltage was applied according to the procedures given in IEC 230.
- The cable sample withstood without failure **10**positive and **10** negative voltage impulses of **325kV peak value,1.2/50μ Sec.**
- After the impulse test , the cable sample was subjected at ambient temperature to a power frequency voltage test of **2.5 U_o (95 kV)** for **15 minutes.**

M. Abd El Ghany
T. Tahoun



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- The impulse voltage of lightning standard shape 1.2/ 50 μ sec was generated by an impulse generator of 12 stages 180 k.joules ,2400 kV . The block diagram of the test system shown in Fig. (5).
- The cable sample withstood the applied impulses and A.C voltages without failure.

7.2.1) HOT SET TEST :

- Two test pieces of XLPE insulation were cut and shaped as dumb-bell as described in IEC 840 subclause 4.9 and IEC 811-2-1 clause 9 as shown in Figure (6), two mark lines were drawn on each test sample. Then,test samples were put in an air oven at $(200 \pm 3)^{\circ}\text{C}$. for 15 min. Suitable weights were hanged on each test sample to achieve a tensile strength of 20 N/cm².

The elongation between the two mark lines was measured and must not exceed 175% and the sample was cooled at room temperature for 5 min . The maximum permanent elongation must not exceed 15% .

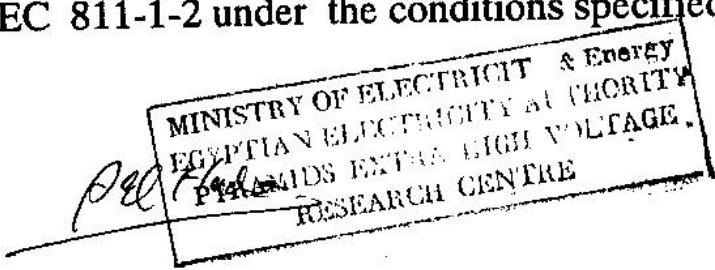
- The test samples of XLPE insulation met the requirements of IEC 840 ,Table VI . The Hot set test results are shown in Table (1).

7.2.2) Ageing Procedure and preparation of test samples :

The ageing treatment was carried out in accordance with clause 8 of IEC 811-1-2 under the conditions specified in table IV .

H.AbdWojdy

F.Tahoun



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The test results are mentioned in Table[1].The test results of XLPE insulation met the requirements of IEC publication No : 840.

7.2.2.1) Measurement of Resistance of Semi - Conducting Layers :

-The resistance of semi-conductive layers,outer and inner of the insulation were measured for both unaged and aged conditions according to the procedure mentioned in subclause (5.6.2) Appendix B of IEC Publication No : 840 (1988).

The volume resistivity(ρ) in Ohm-meter was calculated by using the following formula :

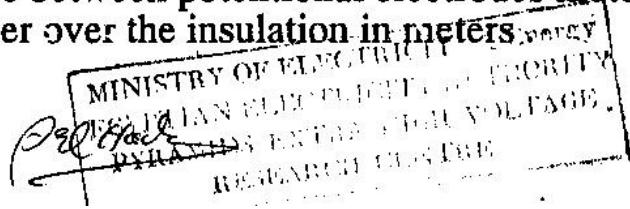
- Conductor screen:

$$\rho = \frac{R \times \Pi \times (D-T) \times T}{2 \times L}$$

Where :

- R is the resistance in ohms.
- L is the distance between potential electrodes meters.
- D is the diameter over the insulation in meters.

M. Abd Elaziz
F. Fahoum



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- T is the average thickness of screen in meters.

- *insulation screen* :

$$\rho = \frac{R \times I \times (D + T) \times T}{L}$$

Where

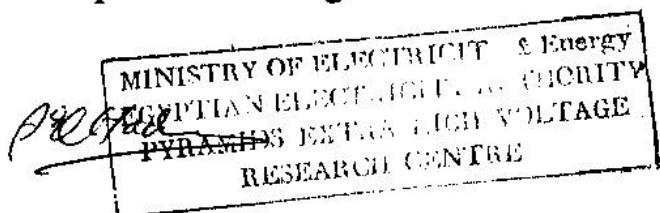
- R is the resistance in ohms.
 - L is the distance between potential electrodes in meters
 - D is the diameters over the insulation in meters .
 - T is the average thickness of screen in meters .
-
- The test samples are shown in Fig.(7)&(8).
 - The test results are mentioned in Table [2].

8- Conclusions :

- The test specimen of 1x400 mm² copper conductor, XLPE insulated power cable with copper sheath of rated voltage 66/38 kV manufactured by EGYTECH CABLES (EL SEWEDY) met the requirements of electrical type tests mentioned in this report according to the IEC standard .

M. Abd El Dayem

F. Tahoun



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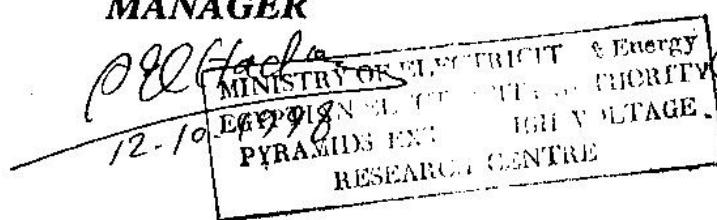
- These tests were carried out for the request of EGYTECH CABLES (EL SEWEDY) without any obligations on the Egyptian Electricity Authority.

- **TEST ENGINEERS :**

M. Abd Elaziz
F. Tahoun

**EXTRA HIGH VOLTAGE
RESEARCH CENTER
MANAGER**

**GENERAL DIRECTOR OF
RESEARCH & ELECTRICAL
TESTING**



3772.

Table [1]

**Test results of Hot Set and Mechanical Characteristics of
insulation and sheath materials of 66 kV Cable :**

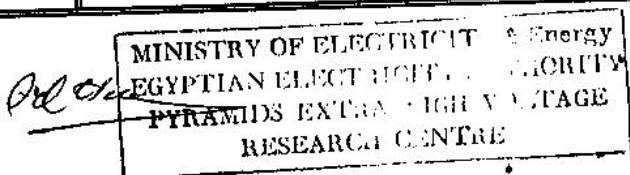
Test	XLPE Insulation		Sheath. Material	
	Required by IEC	Test Results	Required by IEC	Test Result
Hot Set Test :				
- Max. Elongation under load.	175 %	165 %	---	---
- Max. Permanent elongation .	15 %	11 %	---	---
Mechanical Characteristics of Insulation Materials :				
a. Without Ageing :				
- Tensile Strength (N/m ² minimum).	12.5			
- Elongation at break (%) minimum).	200	516.95	350	1042
b. After Ageing :				
- Variation of tensile strength (max.).	± 25	1.2	---	---
- Variation of Elongation at break Maximum (%).	± 25	199.4 %	---	---
- Residual value of Elongation at break Minimum (%).	-----	-----	350	399

Table [2]

**Test results of volume resistivity for
Semi Conducting Layer**

Semiconductor Screen for :	required value acc. to IEC 840/(1988)	volume Resistivity(Ω.m)	
		Before Ageing	After Ageing
- Conductor .	≤ 1000 Ω . m	37	27
- Insulation .	≤ 500 Ω . m	25	20

N. Abd El Ghany
F. Tahoun



XLPE before ageing

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Test Tensile Test

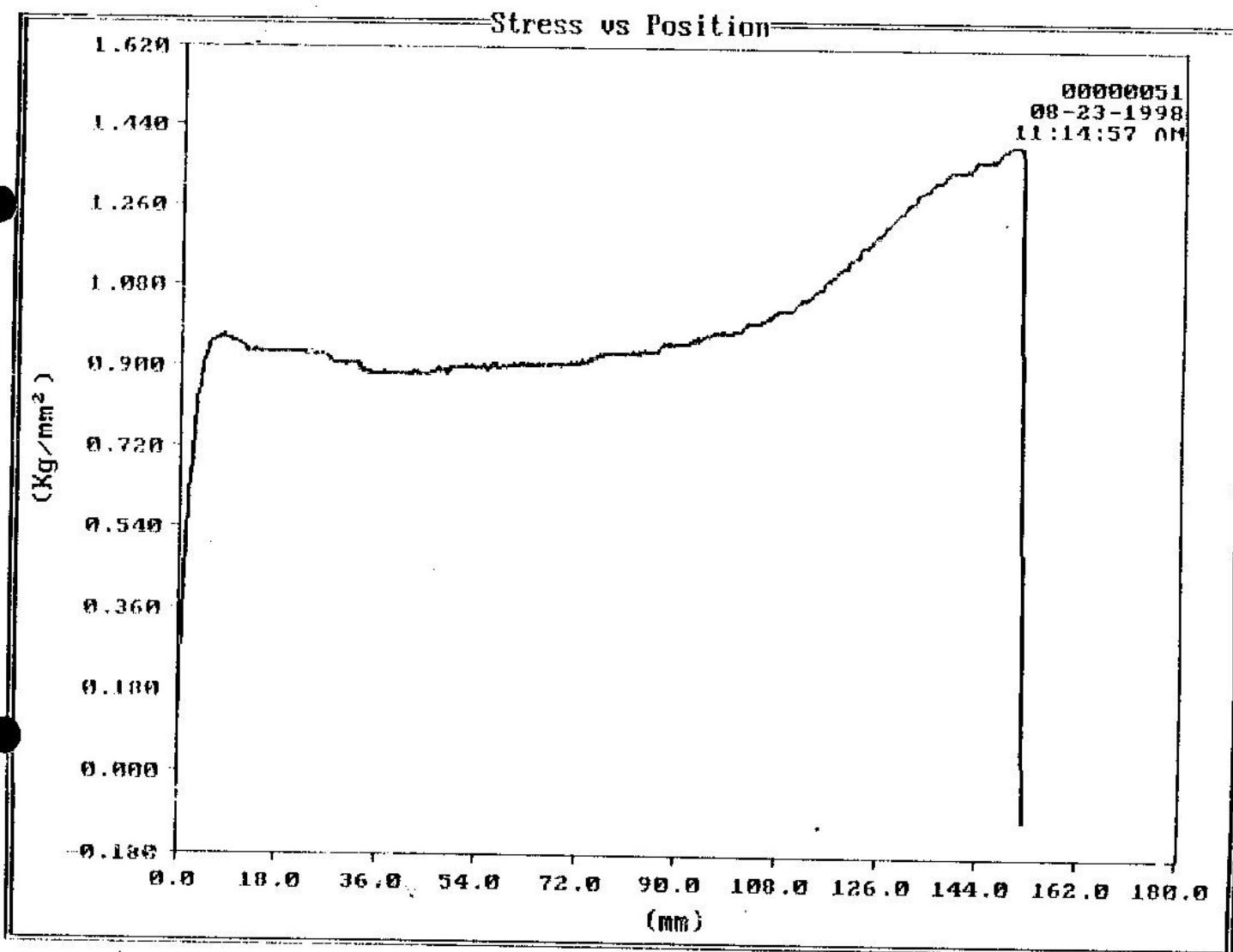
Procedure Tensile test

Test Date 08-23-1998
Test Time 11:14:57 AM
Elapsed Time 00:00:37

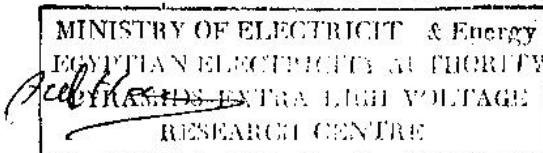
Tested By E.H.V.R.C
Test Counter 00000051
Area 6.0000 mm²

Tensile Strength 1.41540 Kg/mm²
Total Elong 516.95 %

Peak Load 8.5 Kg
Init Punch Len 29.500 mm



M. Abd [Signature]
F. Tahoun



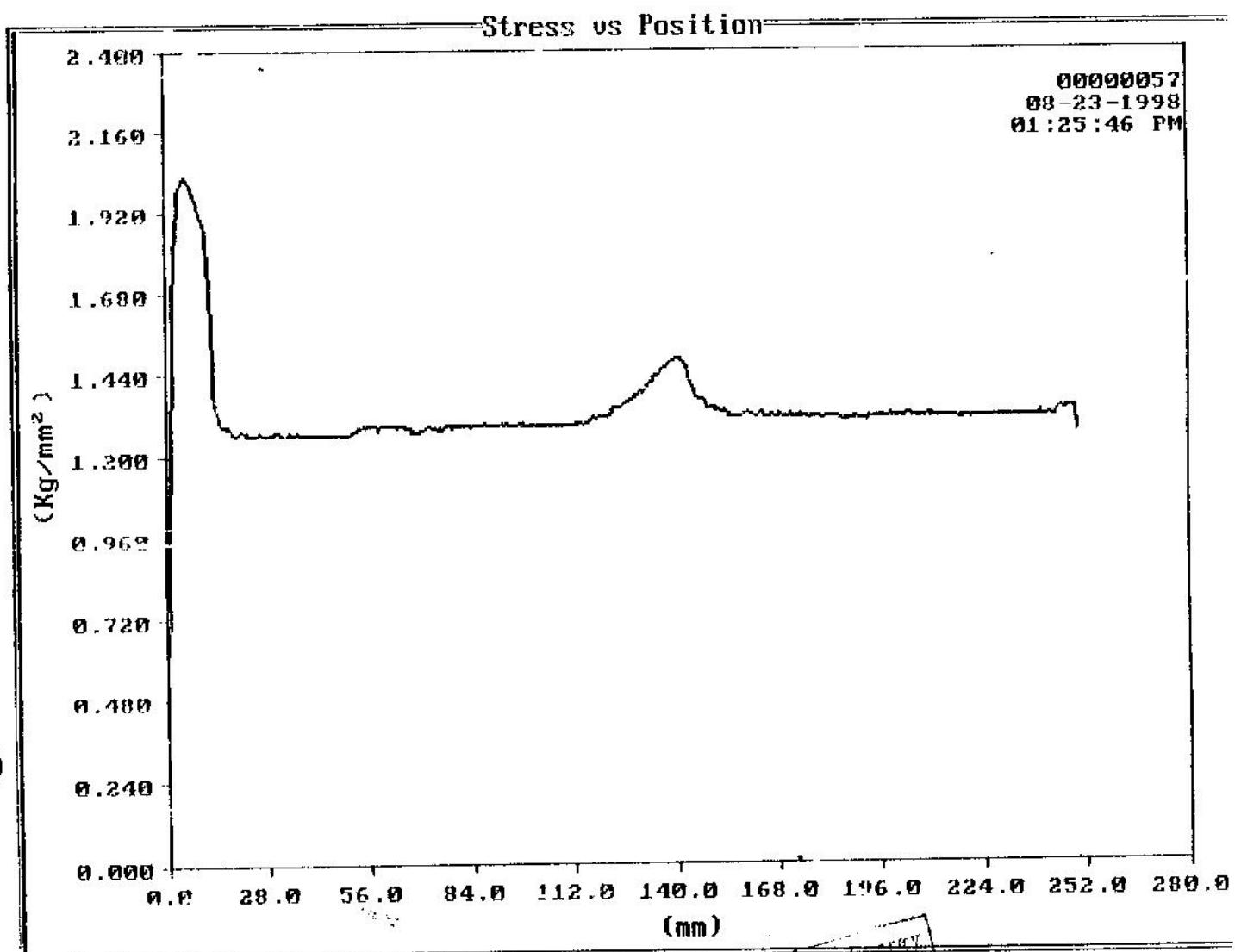
H.D.P.E
before ageing

Pog (13/24)

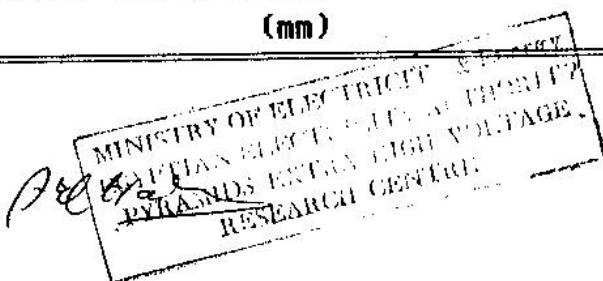
Test Tensile Test

Procedure Tensile test

Test Date	08-23-1998	Tested By	E.H.V.R.C
Test Time	01:25:46 PM	Test Counter	00000057
Elapsed Time	00:01:00	Area	5.8800 mm ²
*Tensile Strgth	2.02590 Kg/mm ²	Peak Load	11.9 Kg
*Total Elong	1086.96 %	Init Punch Len	23.000 mm



Rabab Dajra
F. Tahoun

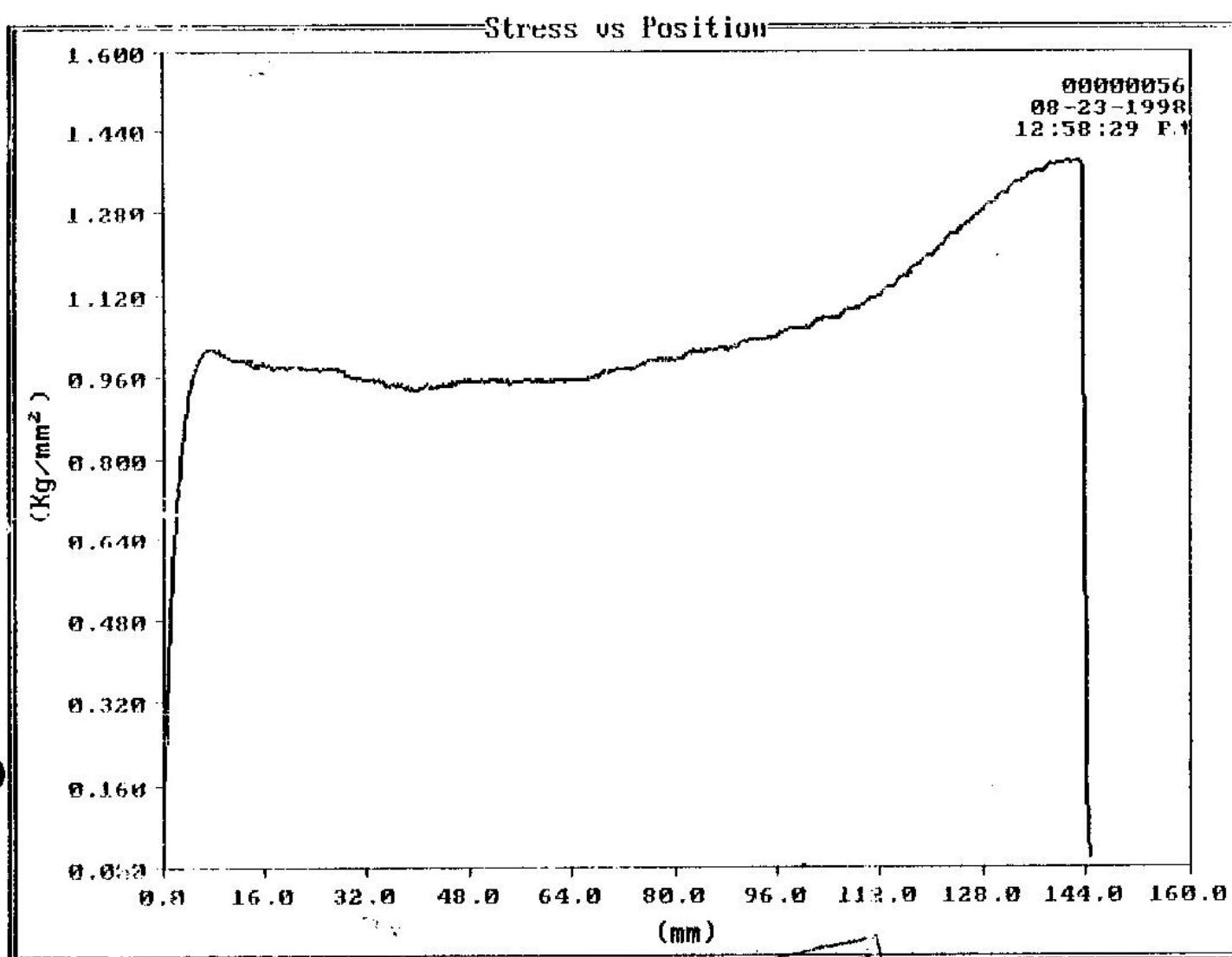


XLPE after ageing

Test Tensile Test
Procedure Tensile test

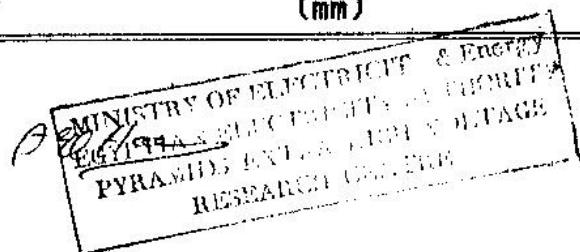
(14224)

Test Date	08-23-1998	Tested By	E.H.V.R.C
Test Time	12:58:29 PM	Test Counter	00000056
Elapsed Time	00:00:35	Area	7.2000 mm ²
Tensile Strength	1.39660 Kg/mm ²	Peak Load	10.1 Kg
Total Elong	517.30 %	Init Punch Len	23.700 mm



M. M. M. El Sayed

F. Tahoun



Test Tensile Test
Procedure Tensile test

H.D.P.E
after ageing

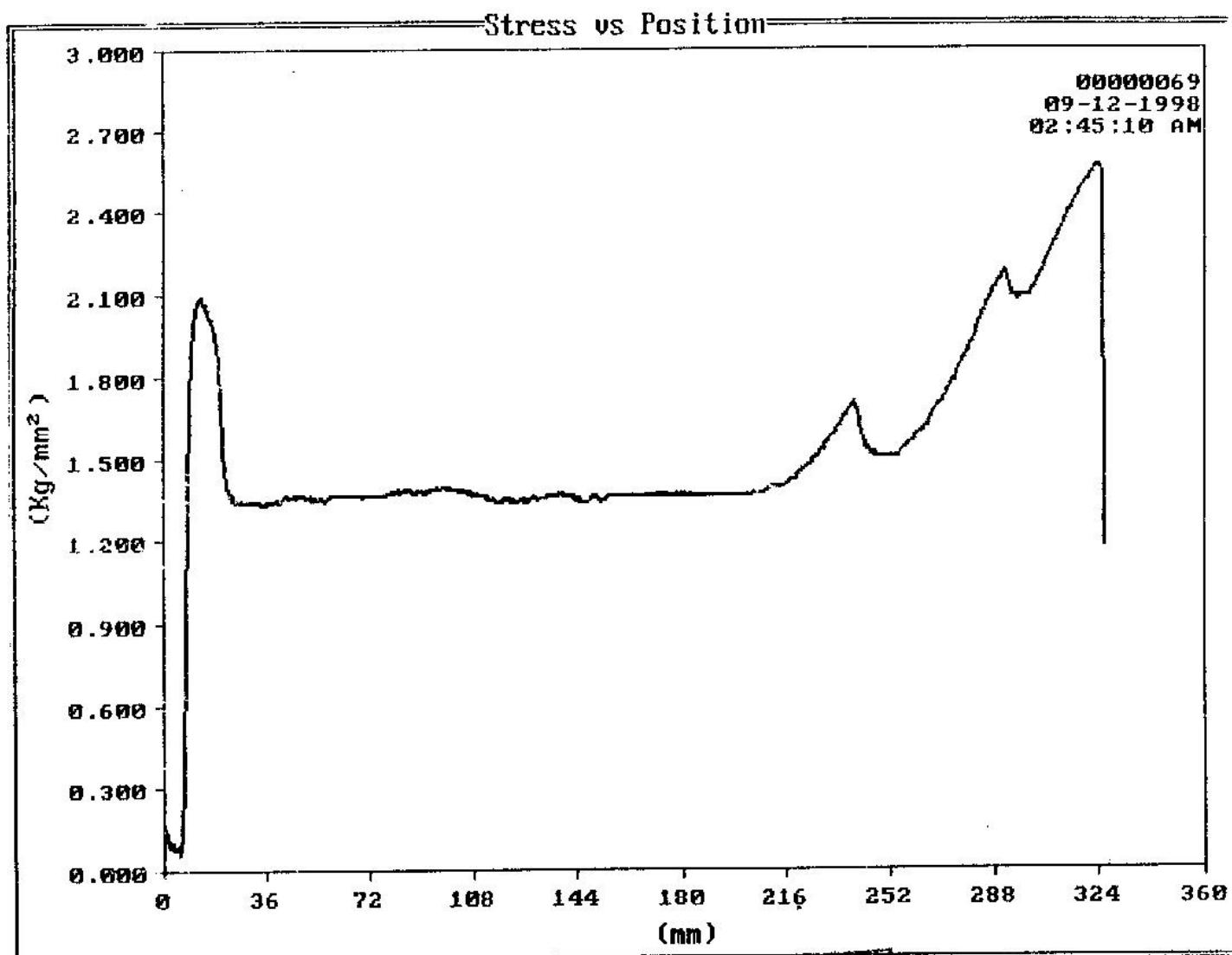
(15/24)

Test Date 09-12-1998
Test Time 02:45:10 AM
Elapsed Time 00:01:38

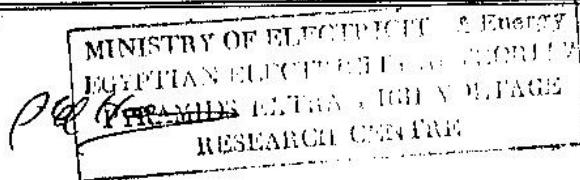
Tested By E.H.V.R.C
Test Counter 00000069
Area 5.2000 mm²

Tensile Strngth 2.5638 Kg/mm²
Total Elong 1042 %

Peak Load 13.3 Kg
Init Punch Len 31.400 mm



M. Abd Elaziz
F. Tahoun





مركز أبحاث الجهد الفائق

PHVRC
E.E.A. A.R.E

Impulse Voltage Test Report

Date : / 9/ 1998

Report No (٢٣/٩٨).

- Subject :

Lightning impulse voltage test on 66 kV Power cable with copper sheath
For EGYTECH Co.

- Test Voltage Value : 325 KV.

- Atmospheric Correction Factors :

- Air density correction K_d = ----- Humidity Correction K_h = -----
- Correction factor of test voltage K = -----
- Test voltage after correction = 325 KV.

- Test Equipments & Apparatus :

- Impulse generator : 2400 KV & 130 KJ

- Types of test wave :

- Lightning impulse 1.2/50 μ Sec .

- Test result :

- The test specimen passed the withstand lightning impulse voltage test wave shape 1.2/50 μ Sec. and attached the photographics test results.

Testing Engineers

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EGYPTIAN ACADEMY
PYRAMIDS EXTRA
RESEARCH CENTER
Attest

Director of High Voltage Centre

I.C.T.T & E.E.A.
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CENTRE
12-10-1998

General Manager of Research and
Testing

Test results of 1.2/50 μ Sec. Lightning impulse Voltage
test on 66 kV power cable with copper sheath
For Egytece Co

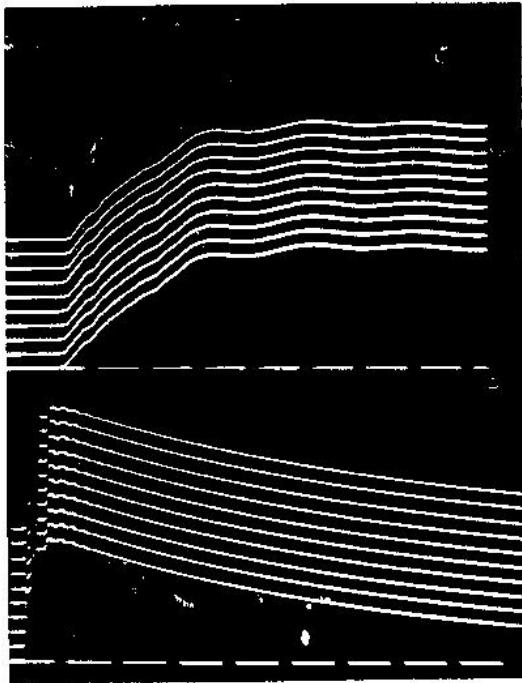


photo No. (203)
Test Voltage(325 kV) positive polarity

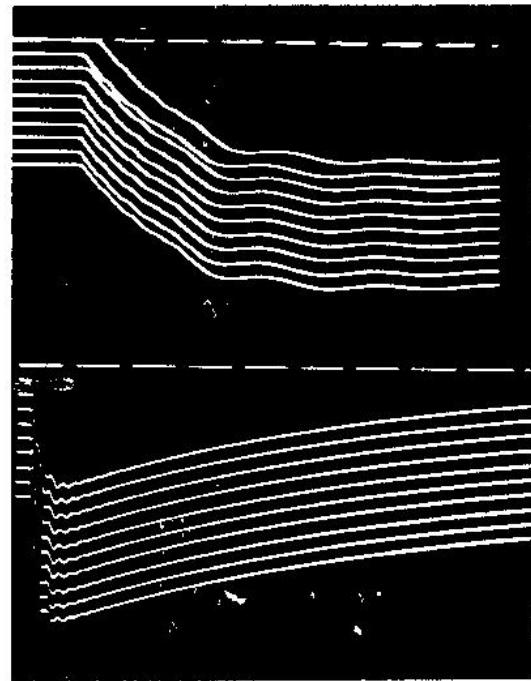
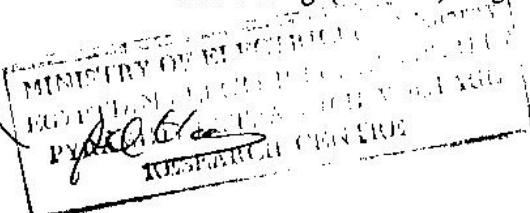
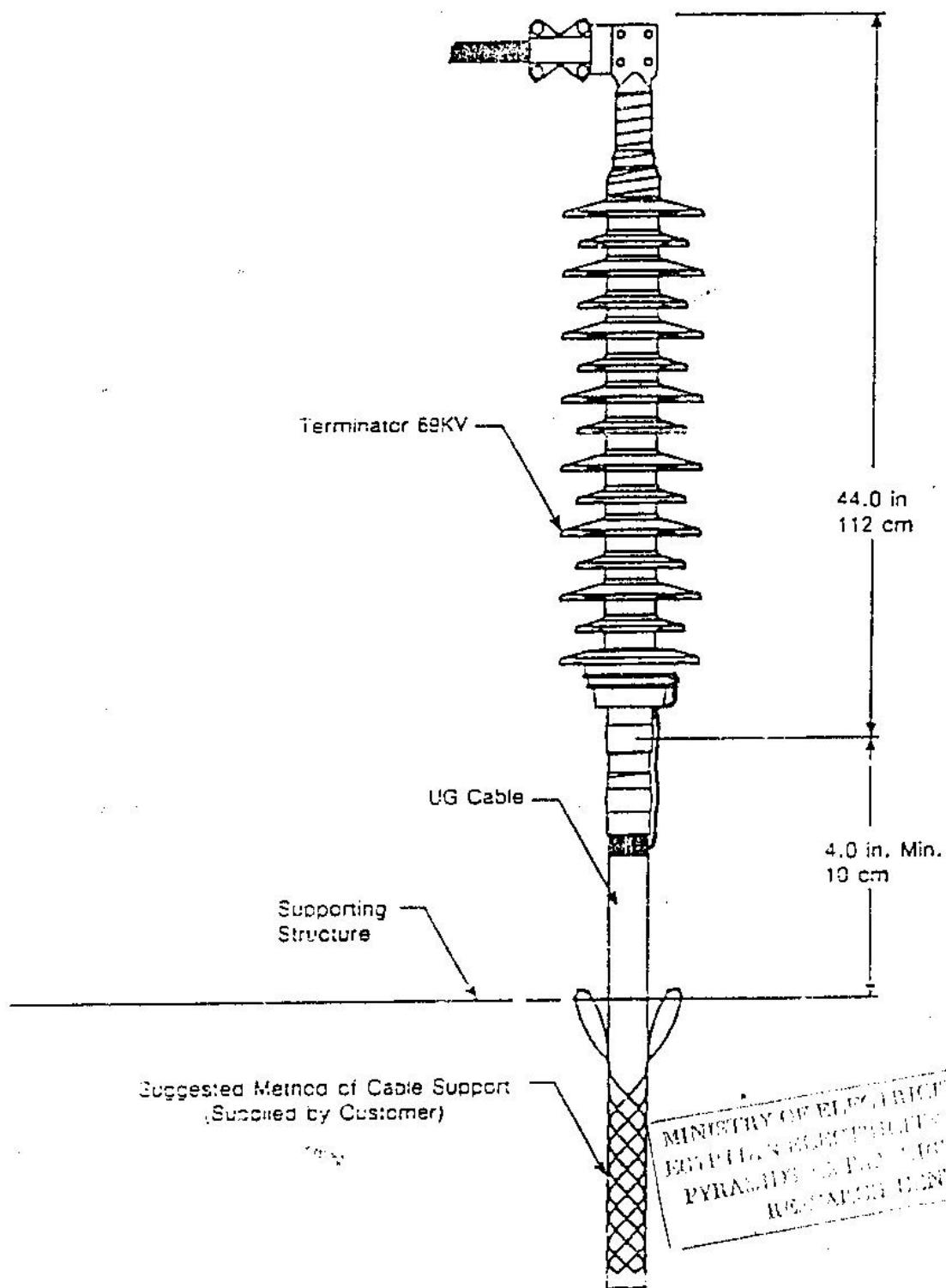


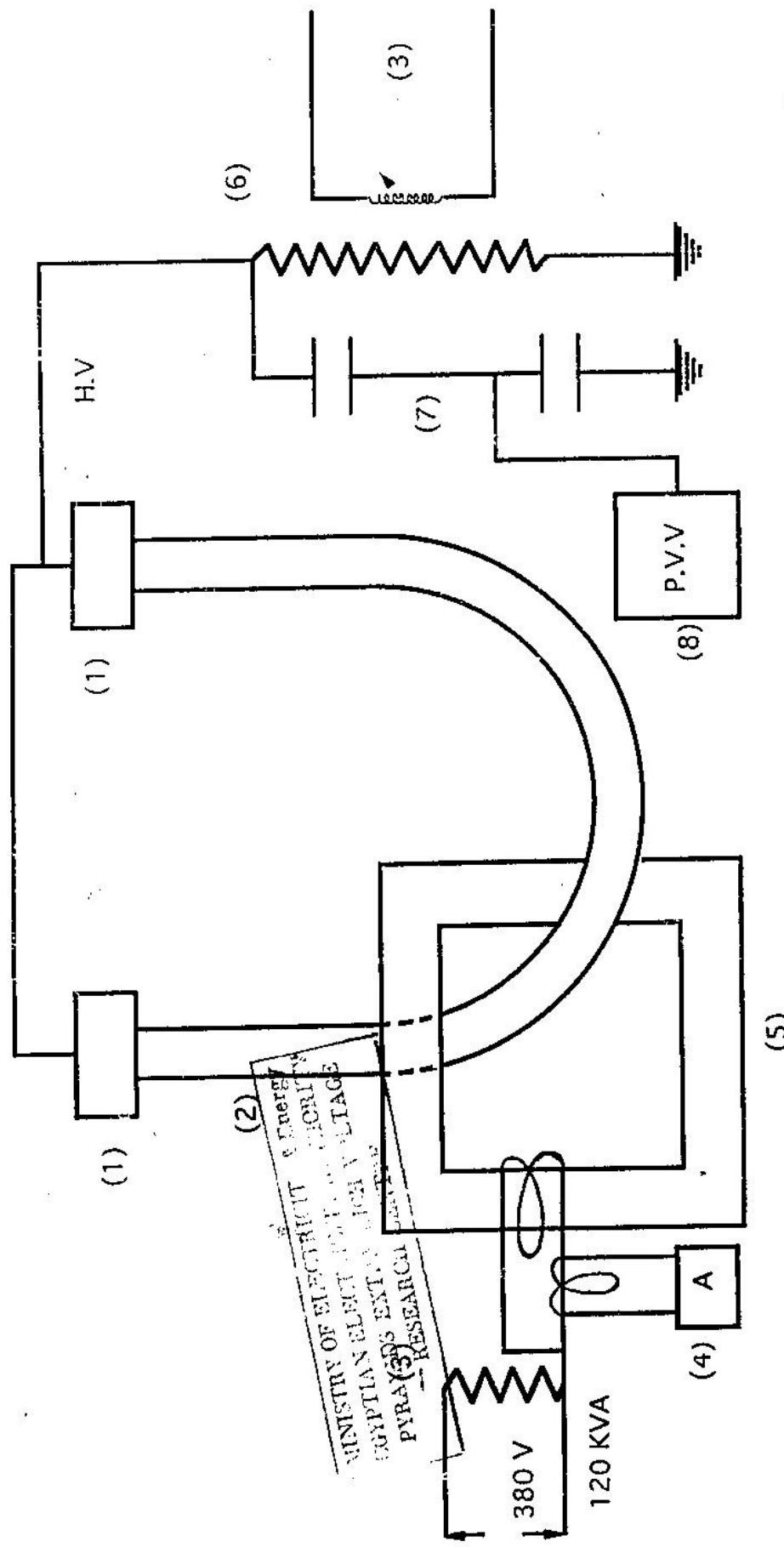
Photo No. (204)
Test Voltage(325 kV) negative polarity





M. A. El Sayed

Fig. (I) : Termination used for the heat cycle & high voltage tests

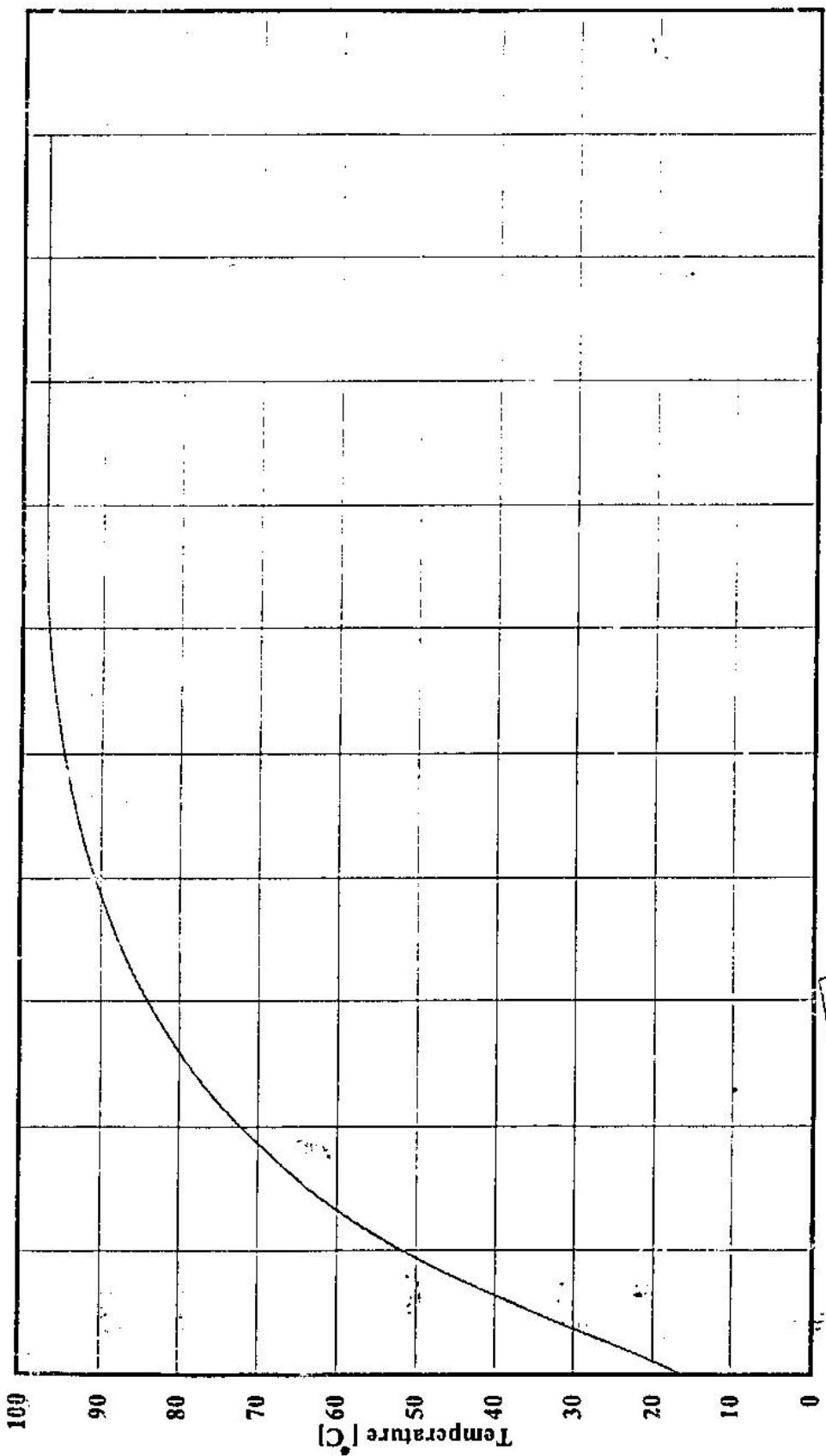


- 5- Transformer core for heating.
- 6- High voltage transformer.
- 7- Capacitor divider for high voltage measurement.
- 8- Peak value voltmeter.

- 1- Cable Terminations.
- 2- Cable Specimen.
- 3- Regulating transformer .
- 4- Current Measuring.

M.A.S.E.J.Y

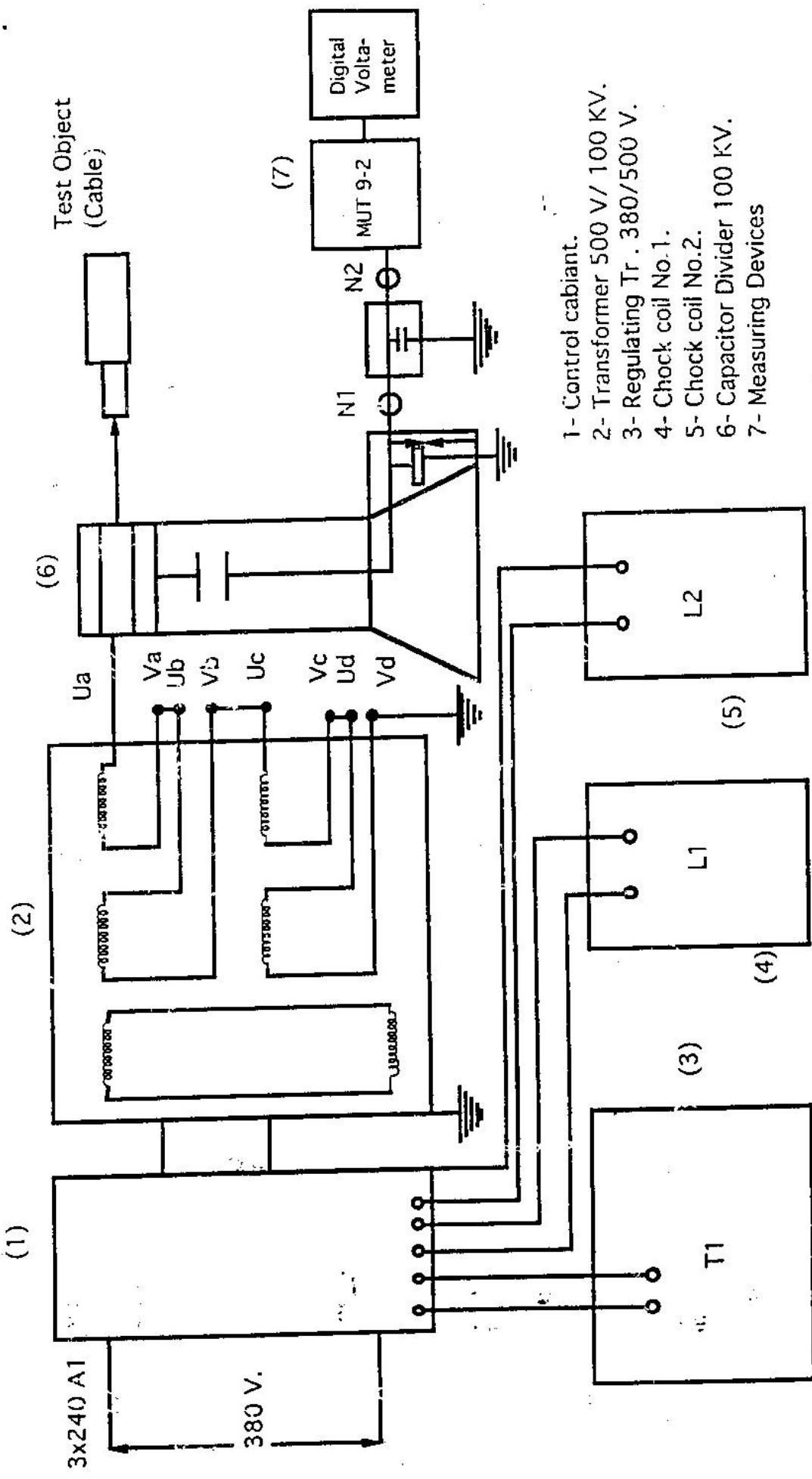
Fig.(2) : Heating cycle test arrangement



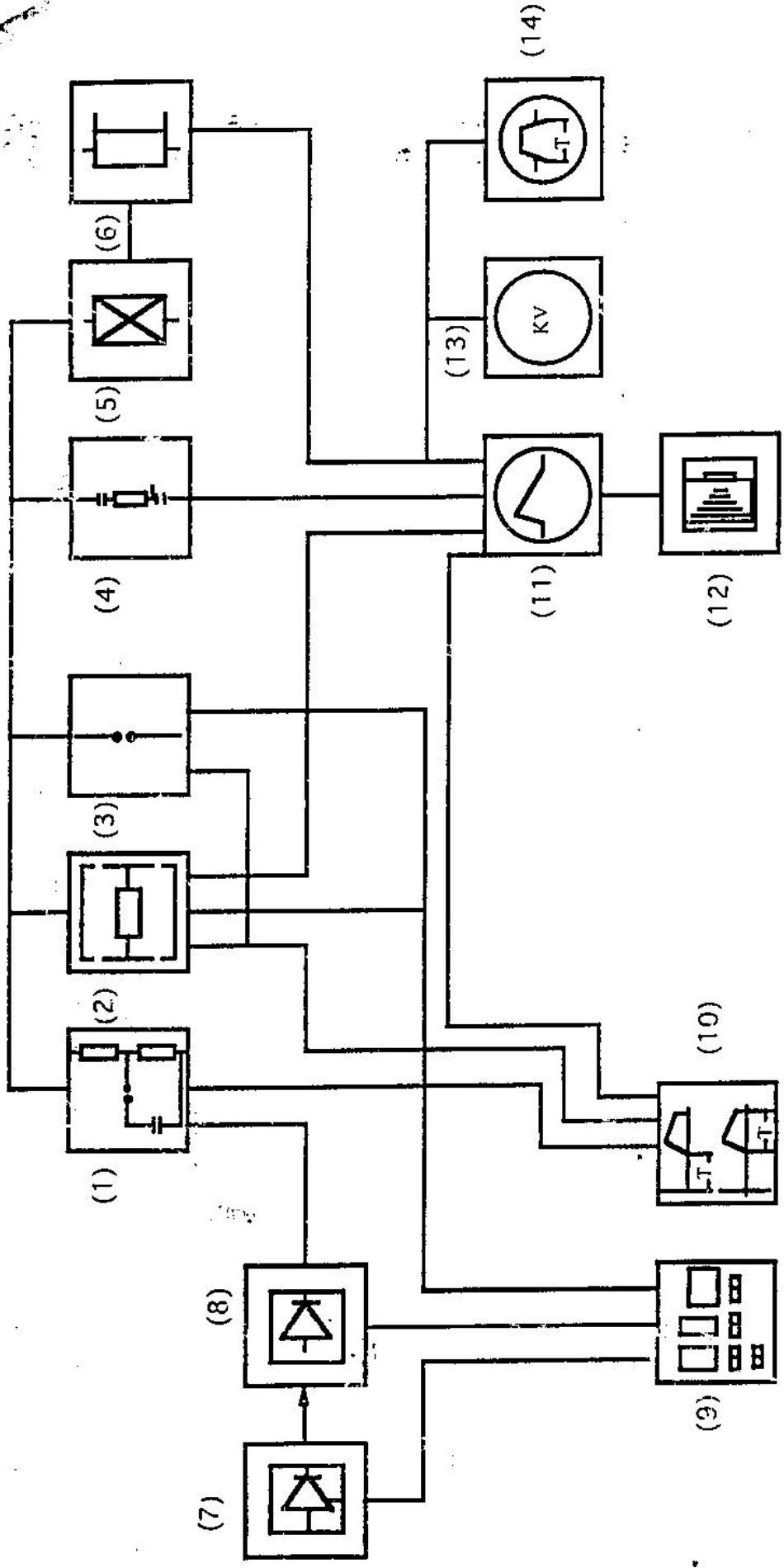
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Fig. (5) : TEMPERATURE RISE FOR A 66 kV CABLE

M. M. Abd El Ghaffar



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 Fig. (4)
 THE A.C SOURCE SCHEMATIC DIAGRAM.



- 1- Impulse generator.
- 2- Chopping gap.
- 3- Sphere gap.
- 4- Impulse voltage divider.
- 5- Test object.
- 6- Shunt.
- 7- Solid state controller.
- 8- Charging rectifier.
- 9- control desk.
- 10- Trigatron trigger device.
- 11- Impulse Oscilloscope.
- 12- Photographic equipment
- 13- Impulse peak voltmeter.
- 14- Time - to - breakdown meter

Fig.(5) : Block diagram of impulse voltage test system.

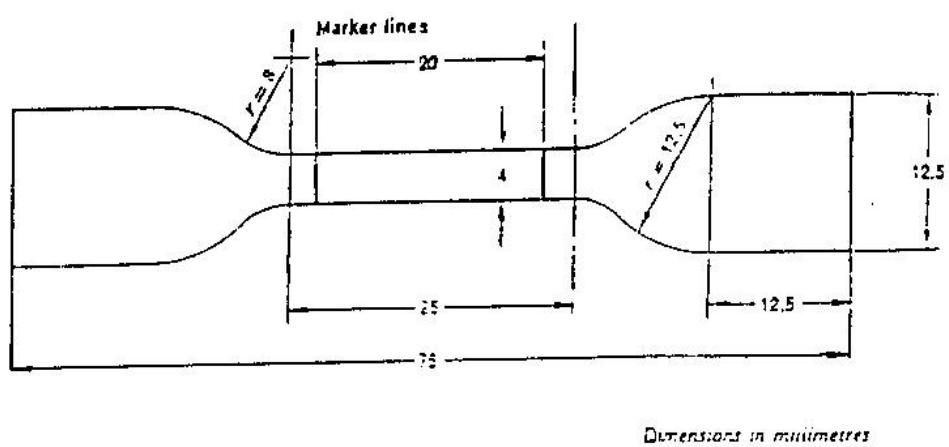
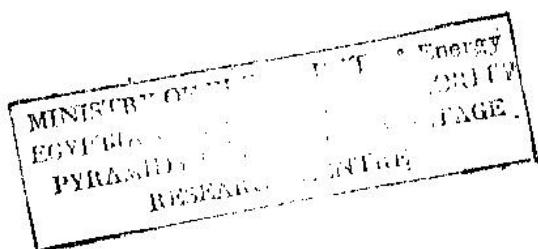


Fig. (6) : Dumb-bell Test Piece.



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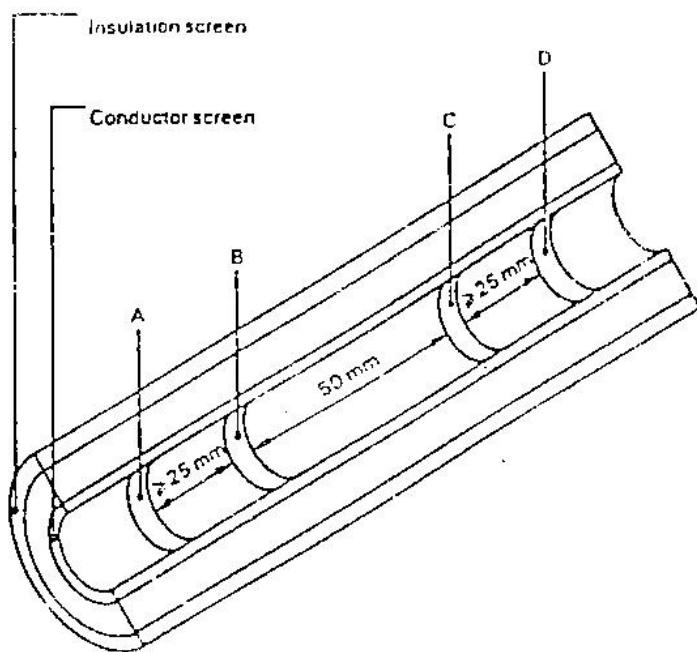


Fig (7) : Measurement of The Volume Resistivity of The Conductor Screen.

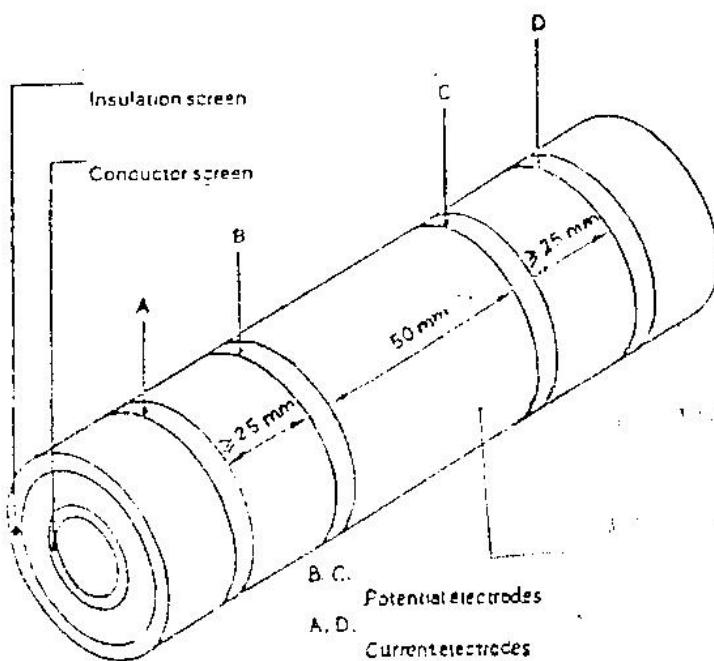


Fig (8) : Measurement of The Volume Resistivity of The Insulation Screen.

Preparation of Samples for Measurement of Resistivity of Conductor and Insulation Screens.

M. Abd El Ghafir