EGYPTIAN ELECTRICITY AUTHORITY

PYRAMIDS EXTRA HIGH VOLTAGE RESEARCH CENTER

TEST REPORT NO.(40/98)

FOR ELECTRICAL TYPE AND SPECIAL TESTS

ON

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

CLIENT : EGYTECH CABLES(EL SEWEDY) COMPANY .

EGYPTIAN ELECTRICITY AUTHORITY

Pyramids Extra High Voltage Research Center
Fax : 00202/ 2616512 - 00202/3869146

TEST REPORT No :(40/98)

DATE : May , 1998.

1- CLIENT :

- EGYTECH CABLES Co.

2- DATE AND PLACE OF TESTS:

- March, April 1998 in EXTRA HIGH VOLTAGE RESEARCH CENTER , GIZA , EGYPT.
- Feb, March, 1998 in EGYTECH CABLES COMPANY

3- TEST SPECIMEN :

- **66** kV power cable , XLPE insulated , single core , copper conductor of **400** mm^2 with LEAD sheath has the following dimensions :

- Specimen length	:	**20**	m.
- Over all diameter	:	**7.6**	cm.
- Copper conductor Over all diameter	:	**23.3**	mm.
- No. of wires	:	**55**	
- Wire diameter	:	**3.23**	mm.
- Inner Semi-Conductor thickness	:	**0.80**	mm.
- XLPE Insulation thickness	:	**17.2**	mm.
- Outer Semi-conductor thickness	:	**1.25**	mm.
- Lead Screen Thickness	:	**2.31**	mm.
- H.D.P.E Thickness	:	**3.55**	mm.

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- The specimen was equipped with two **69** kV terminations shown in Fig.(1) which has the following specifications:

- Length : **85** cm, leakage path : **234** cm.

- No. of sheds : **8/7** , shed's diameters : **26.6** cm,**18** cm.

- Stem diameter : **8.4** cm.

- The test specimen was fixed as a **U** shape on a cable drum of **250** cm hub diameter.

4 - REQUIREMENTS :

- Electrical type tests and special tests according to IEC standard specification

5- STANDARD SPECIFICATIONS :

- IEC 840 (1988) :Tests for power cables with extruded insulation for rated voltage above **30** kV(U_m = **36** kV) up to **150** kV (U_m = **170** kV) .

- IEC 840 : Ammendment **1** (1991), Ammendement **2** (1993)

- IEC 811 : Common test methods for insulating and Sheathing materials of electric cables.

- IEC 270(1981) : Partial discharge measurements.

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- IEC 855 (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*** δ 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 of the semi-conductor layers before and after aging .
6.2.3) Tests for determining the mechanical properties of insulation before and after ageing.

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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 855-3 :

-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* δ 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

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.The sample was heated until the conductor reached **95**°C . ***Tan δ*** 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 ***Tanδ*** is **6.66×10^{-4}** which met the requirement 0f 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.

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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 **2.5** 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 **325**kV peak value,**1.2/50**μ 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.

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- The impulse voltage of lightning standard shape **1.2/ 50** μsec 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±3**)°C. for 15 min. Suitable weights were hanged on each test sample to achieve a tensile strength of **20** N/cm^2.

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 .

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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 potentional electrodes meters.
- D is the diameter over the insulation in meters .

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- T is the average thickness of screen in meters.

- insulation screen :

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

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 mm^2 copper conductor, XLPE insulated power cable with lead 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 .

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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 :***

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12-5-98

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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. Permenant enlogation .	15 %	11 %	----	----
Mechanical Characteristics: of Insulation Materials :				
a.Without Ageing :				
- Tensile Strength (N/m^2 minimum).	12.5	12.9	10	19.8
- Elongation at break (%) minimum).	200	560	300	595
b. After Ageing :				
- Variation of tensile strength (max.).	± 25	5.8	---	---
- Variation of Elongation at break Maximum (%).	± 25	17 %	---	---
- Residual value of Elongation at break Minimum (%).	-----	----	300	897

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	35	20
- Insulation .	≤ 500 Ω. m	22	17

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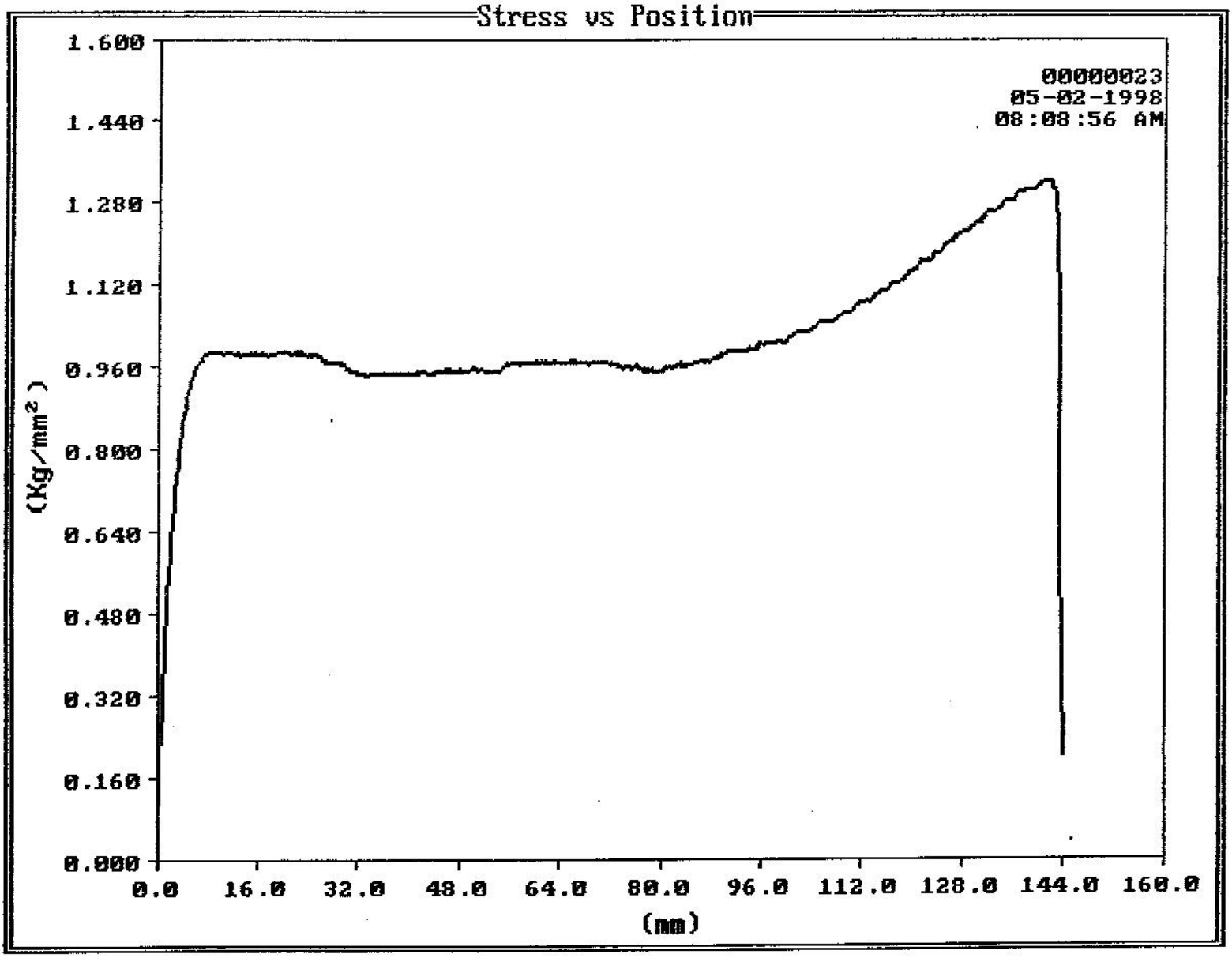
Mechanical Characteristics of XLPE Insulation Before Ageing

Test Tensile Test
Procedure Tensile test

Test Date	05-02-1998	Tested By	E.H.V.R.C
Test Time	08:08:56 AM	Test Counter	00000023
Elapsed Time	00:00:35	Area	7.4000 mm²
Tensile Strgth	1.31990 Kg/mm²	Peak Load	9.8 Kg
*Total Elong	560.19 %	Init Punch Len	25.750 mm



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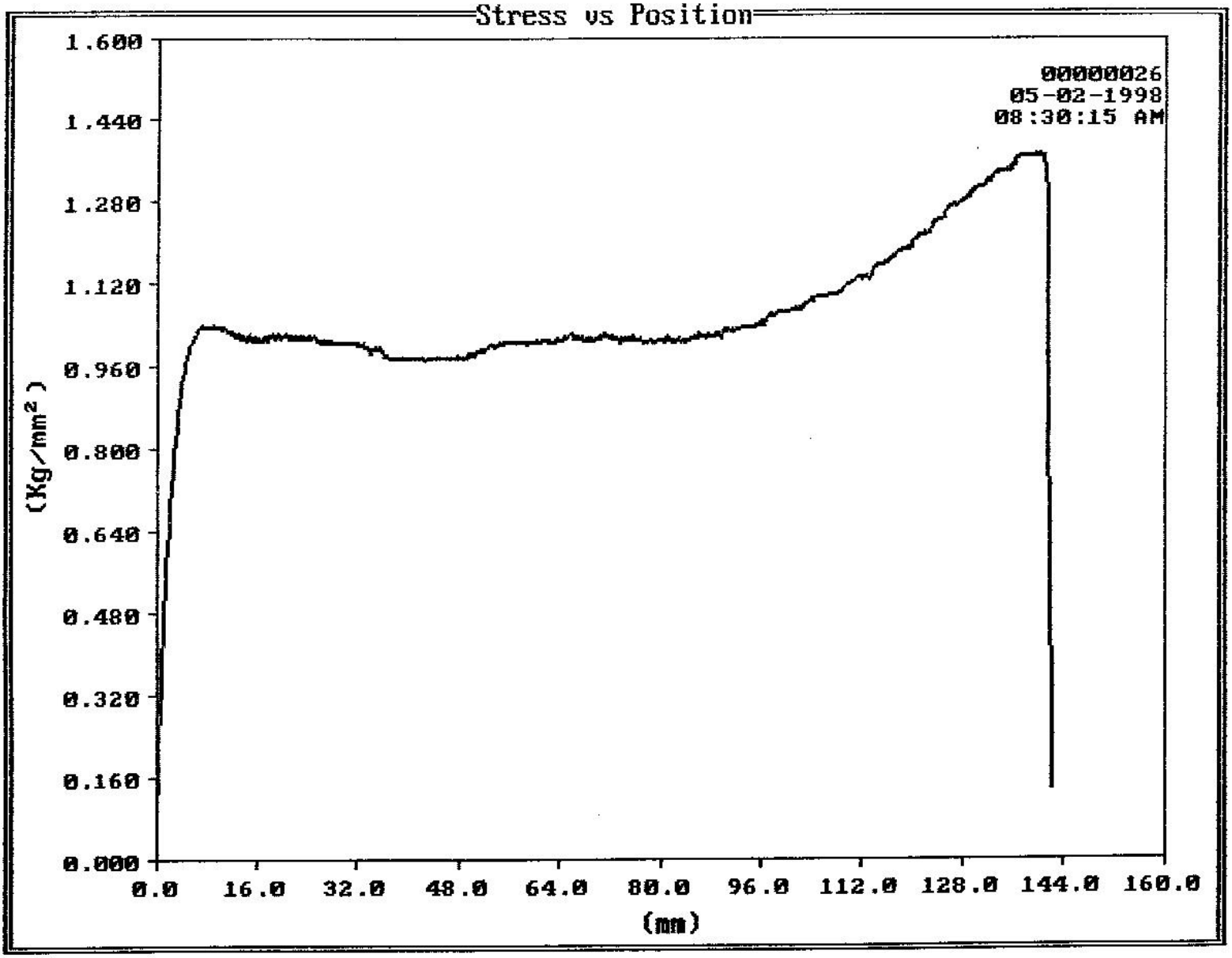
Mechanical Characteristics of XLPE Insulation After Ageing

Test Tensile Test
Procedure Tensile test

Test Date	05-02-1998	Tested By	E.H.V.R.C
Test Time	08:30:15 AM	Test Counter	00000026
Elapsed Time	00:00:34	Area	4.8000 mm²
Tensile Strgth	1.3971 Kg/mm²	Peak Load	6.7 Kg
*Total Elong	464.52 %	Init Punch Len	31.000 mm



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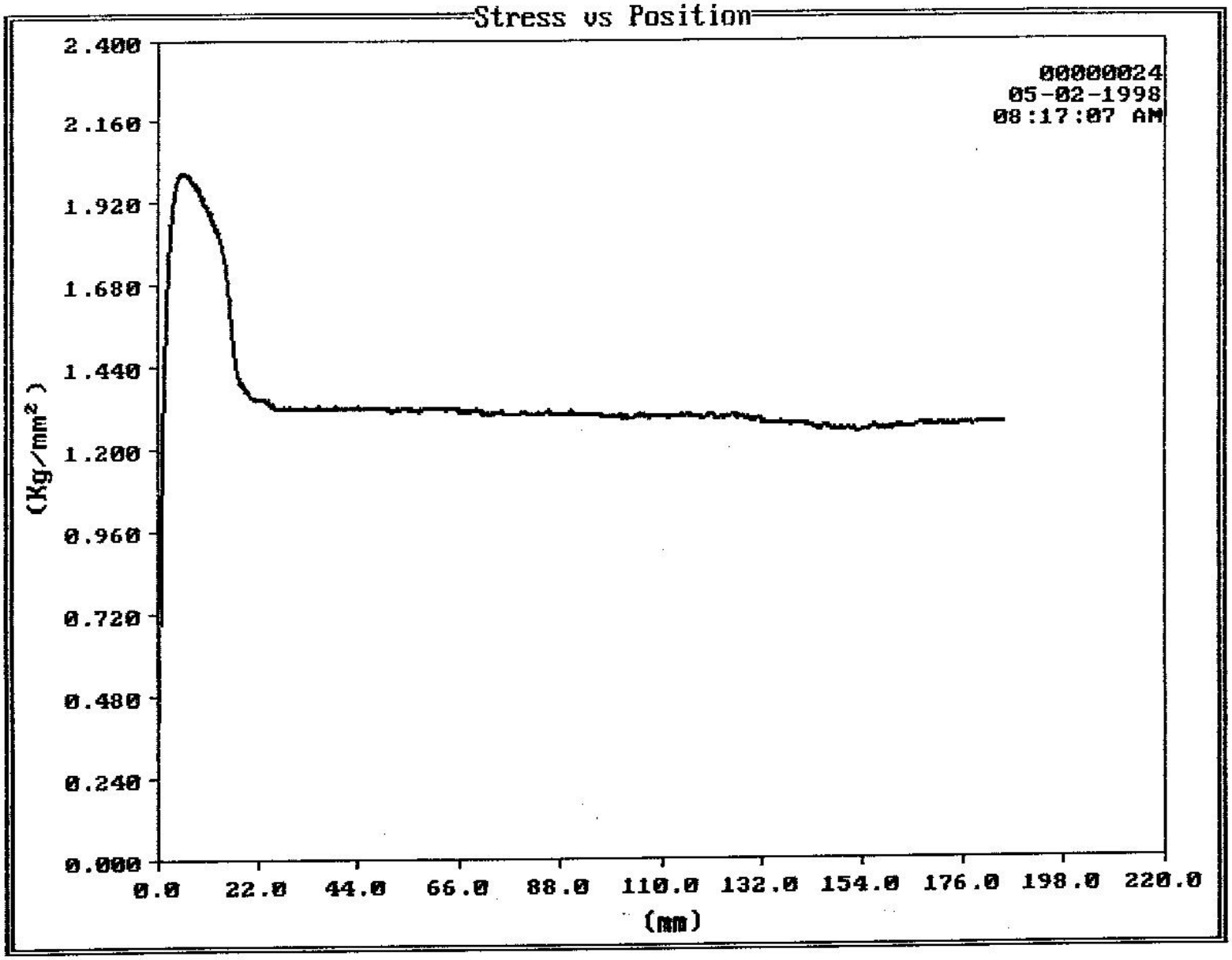
Mechanical Characteristics of Sheath Material Before Ageing

Test Tensile Test
Procedure Tensile test

Test Date	05-02-1998	Tested By	E.H.V.R.C
Test Time	08:17:07 AM	Test Counter	00000024
Elapsed Time	00:00:44	Area	6.2000 mm²
*Tensile Strgth	2.02210 Kg/mm²	Peak Load	12.5 Kg
*Total Elong	595.24 %	Init Punch Len	31.500 mm



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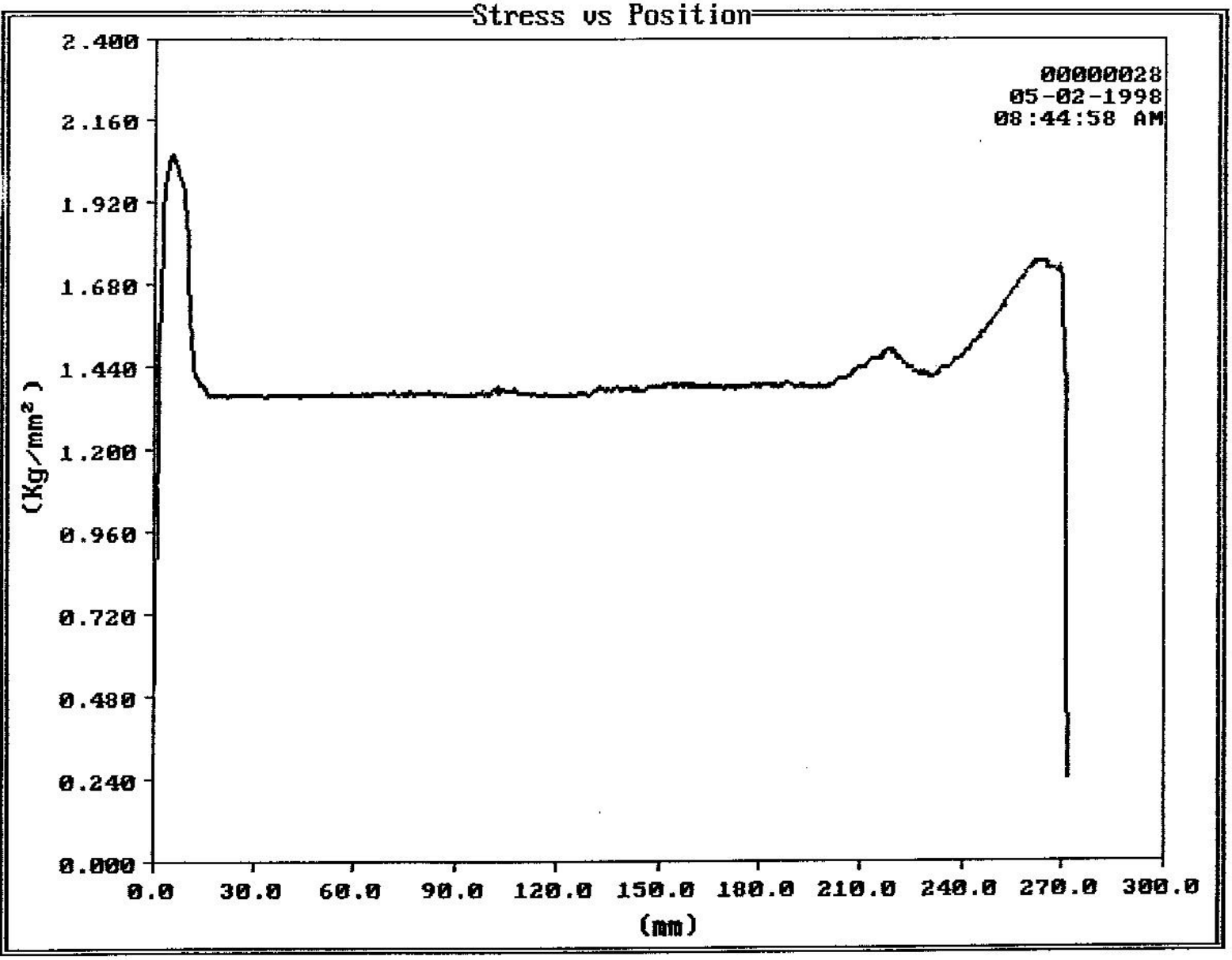
Mechanical Characteristics of Sheath Material After Ageing

Test Tensile Test
Procedure Tensile test

Test Date	05-02-1998	Tested By	E.H.V.R.C
Test Time	08:44:58 AM	Test Counter	00000028
Elapsed Time	00:01:05	Area	5.6000 mm²
*Tensile Strgth	2.05660 Kg/mm²	Peak Load	11.5 Kg
*Total Elong	900.00 %	Init Punch Len	30.000 mm



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مركز ابحاث الجهد الفائق
PHVRC
E.E.A- A.R.E

وزارة الكهرباء والطاقة
هيئة كهرباء مصر
مركز ابحاث الجهد الفائق

Impulse Voltage Test Report

Date : / 5 / 1998 Report No (40/98).

- Subject :
  1.2/50 μSec.Lightning Impulse Voltage test on a cable 66 kV for EGYTECH Company .

-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 & 180 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 μSec. and attached the photographics test results .

Testing Engineers	Director of High Voltage Centre
M.Makim A.Hal	10-5-98 General Manager of Research and Testing

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Test results of 1.2/50 μ Sec. Lightning impulse Voltage
Test on a cable 66 kV
for EGYTECH Company

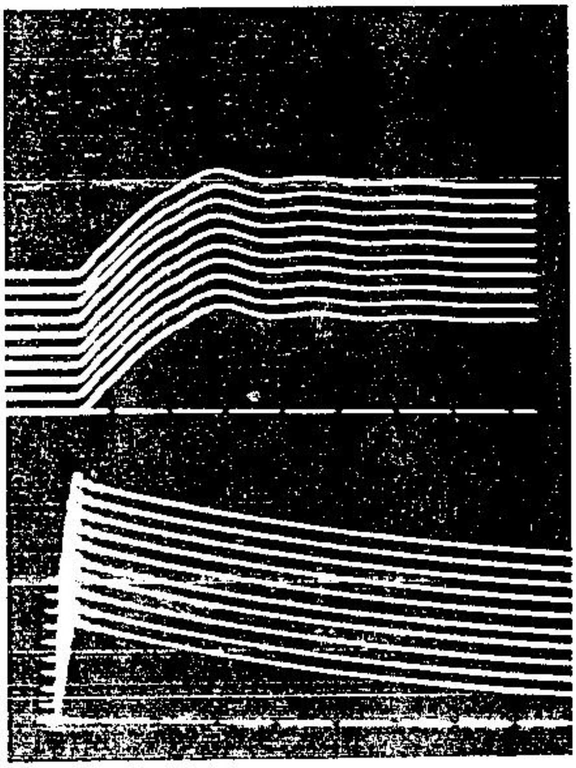

photo No. (31)
Test Voltage 325 KVPolarity Positive

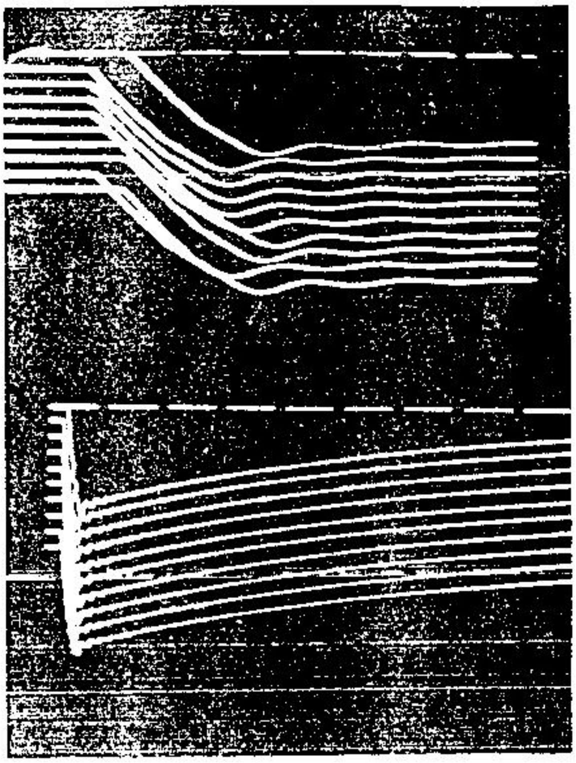

photo No. (32)
Test Voltage 325 KVPolarity negative

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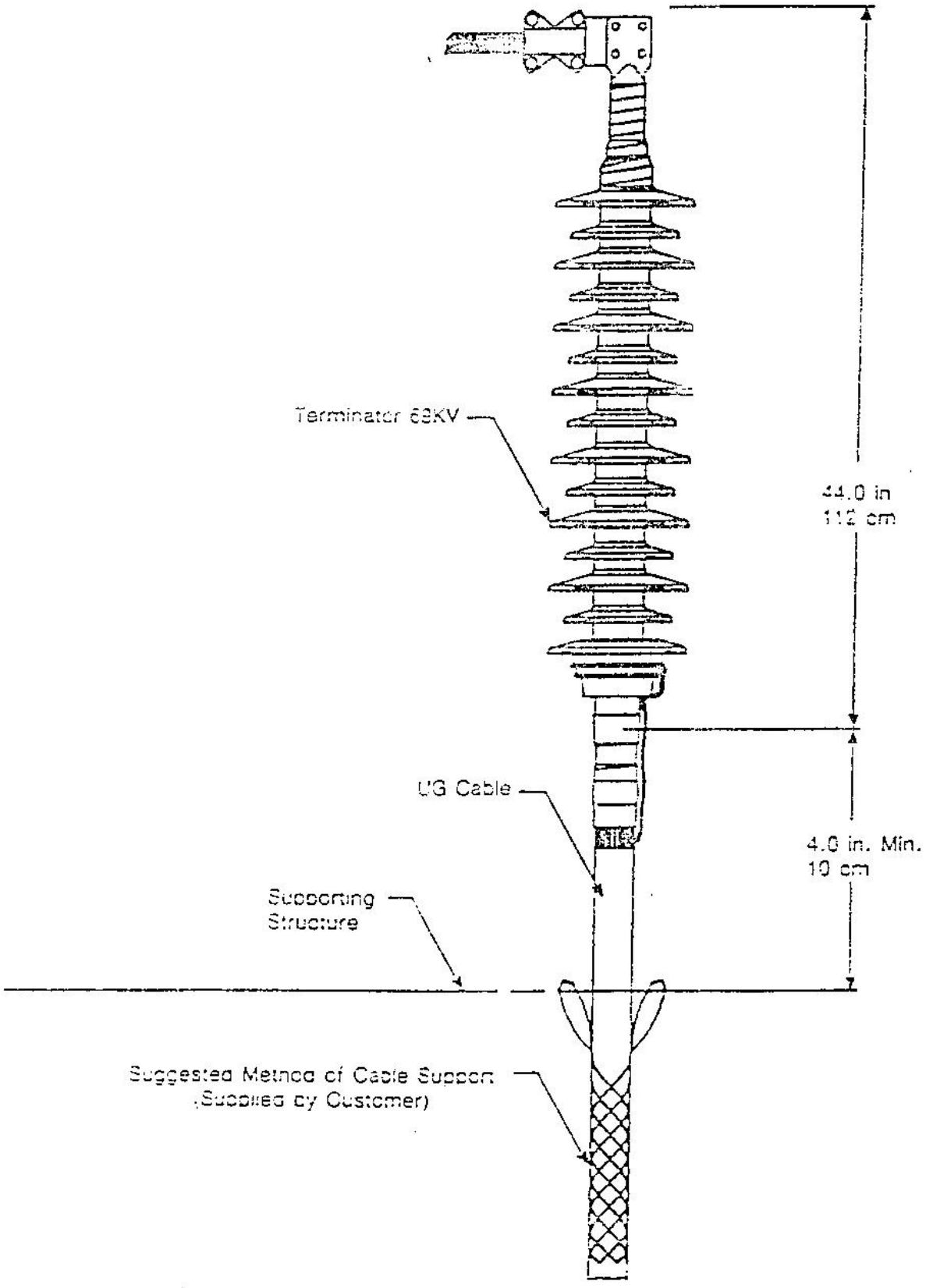

Fig. (1) : Termination used for the heat cycle & high voltage tests

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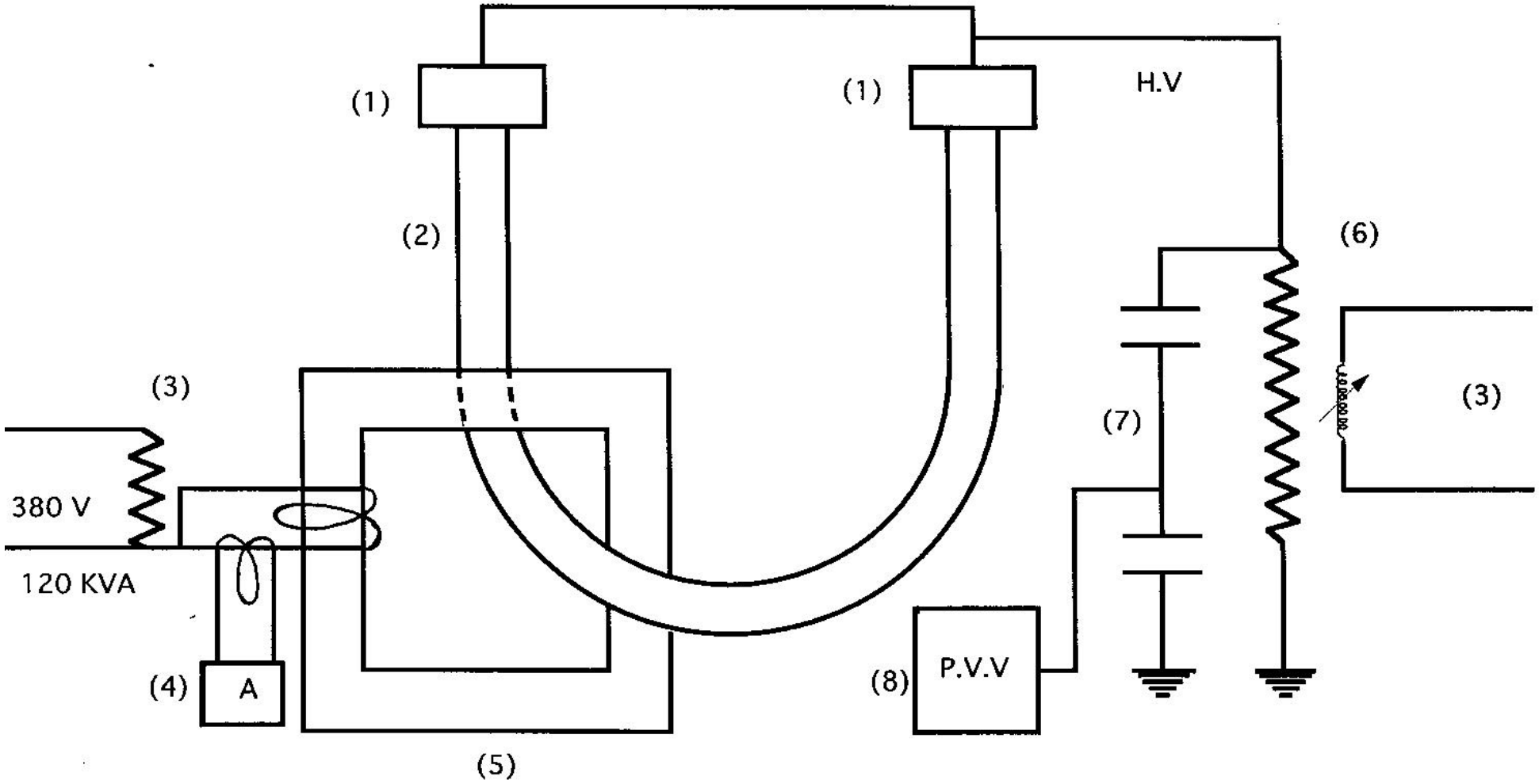

1- Cable Terminations.
2- Cable Specimen.
3- Regulating transformer .
4- Current Measuring.
5- Transformer core for heating.
6- High voltage transformer.
7- Capacitor divider for high voltage measurment.
8- Peak value voltmeter.

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Fig.(2) : Heating cycle lest arrangment .

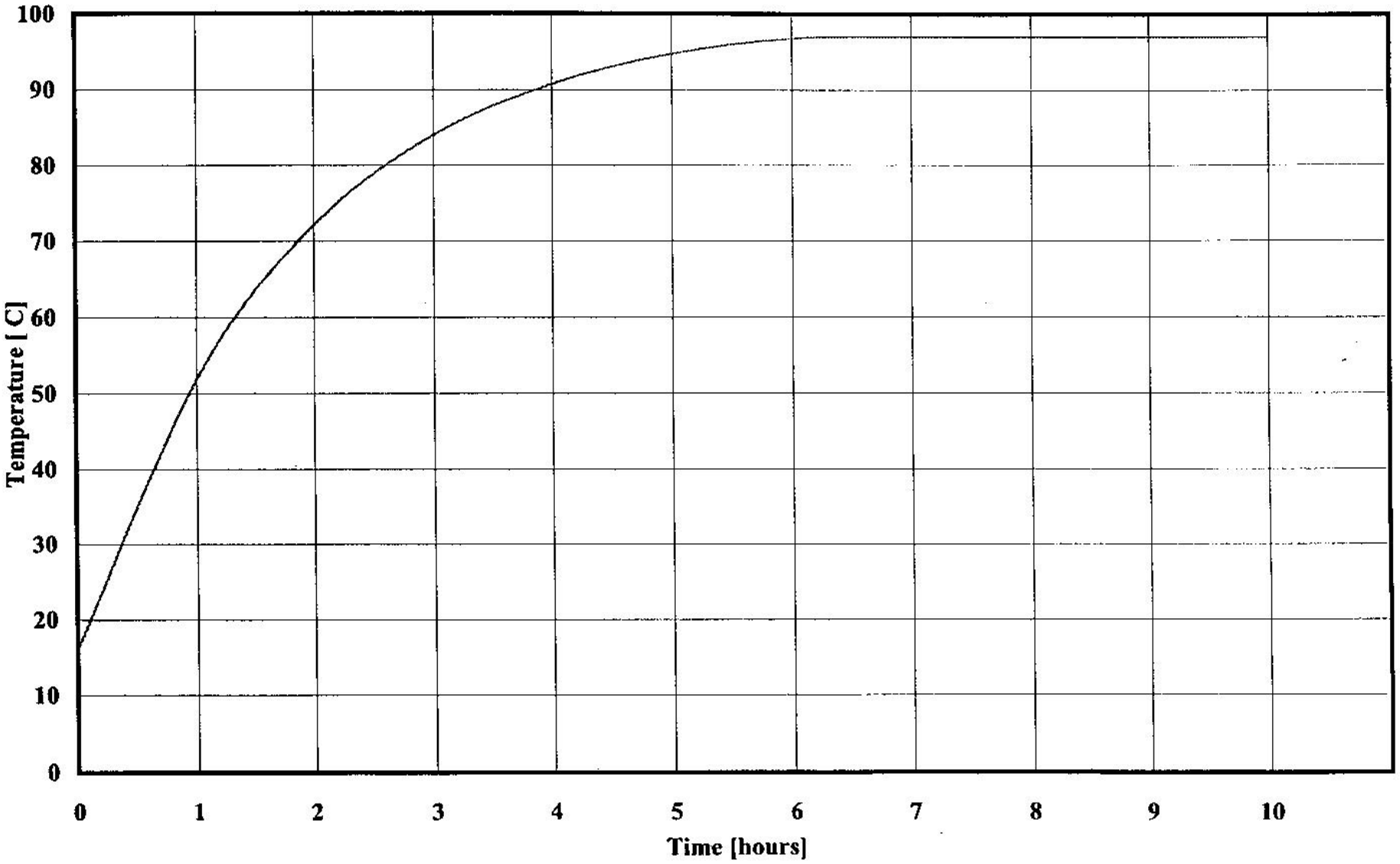

Fig. (3) : TEMPERATURE RISE FOR A 66 kV CABLE

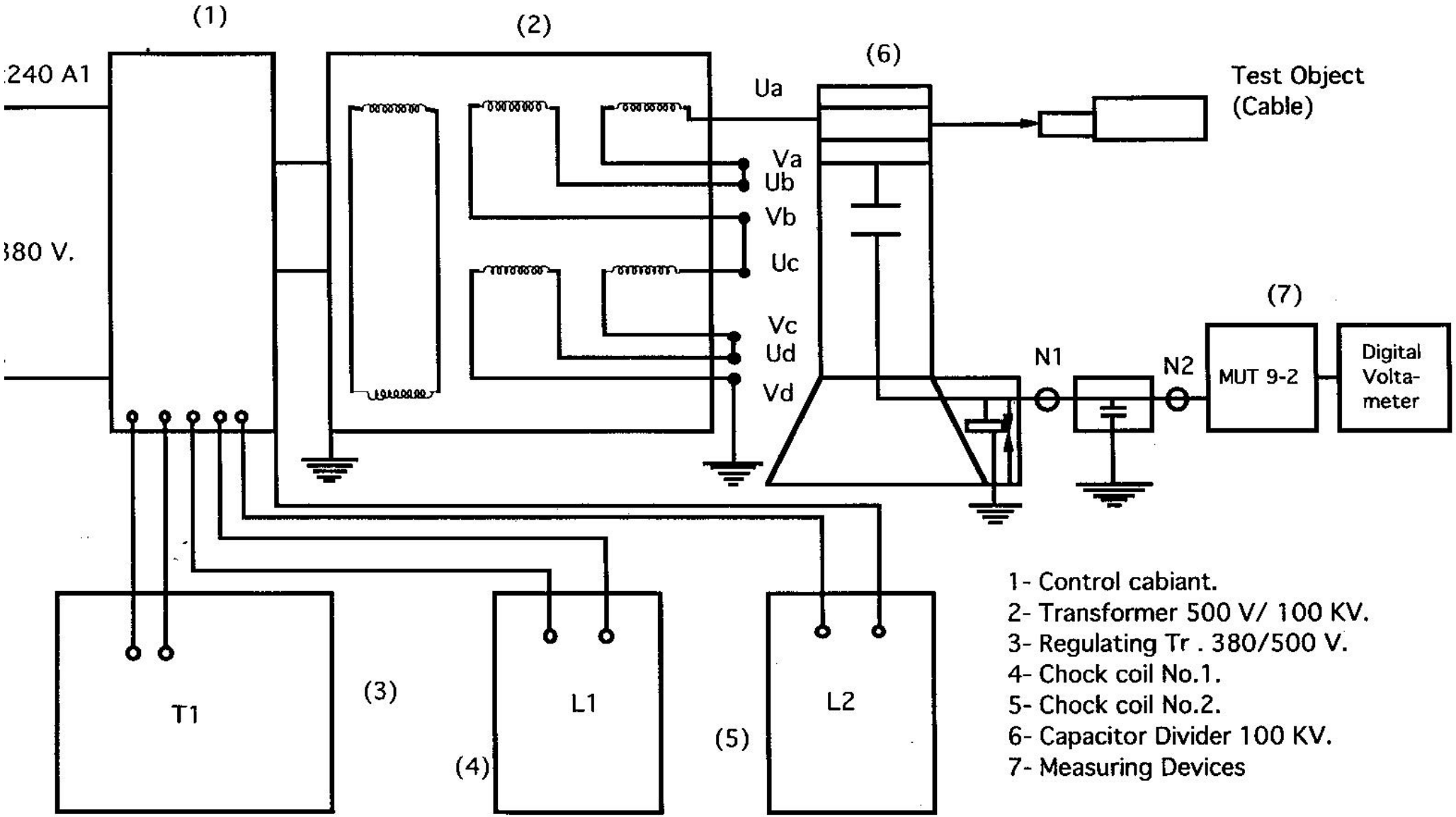

Fig.(4) : The A.C Source schematic diagram .

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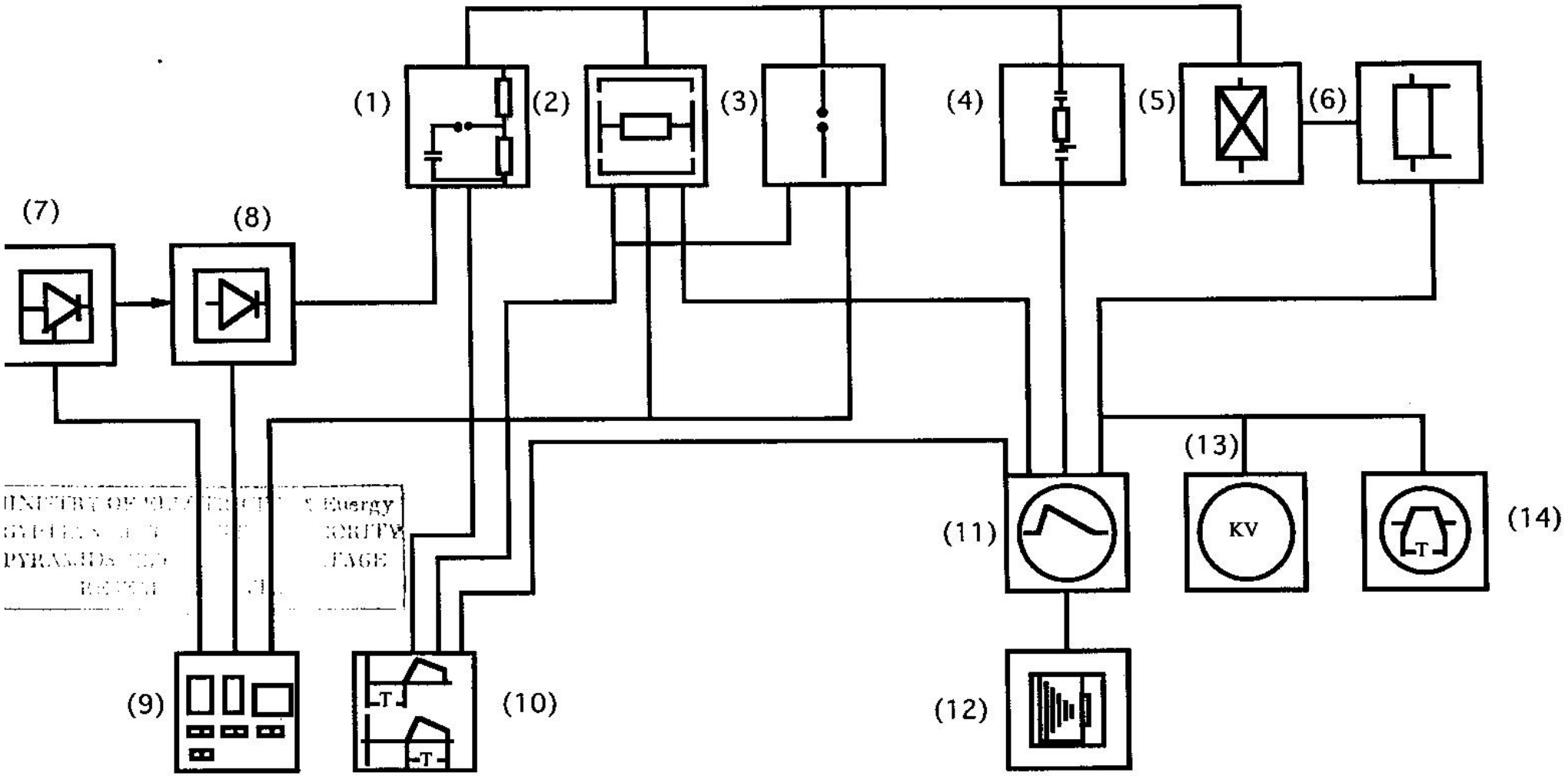

1- Impulse generator.
2- Chopping gap
3- SPhere gap.
4- Impulse voltage divider.
5- Test object.
6- Shunt.
7- Solid state controller.
8- Charging rectifier.
9- control desk.
10- Trigatron trigger device.
11- Impulse Oscilloscope.
12- Photographic equipment
.13- Impulse peak voltmeter.
14- Time - to -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

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

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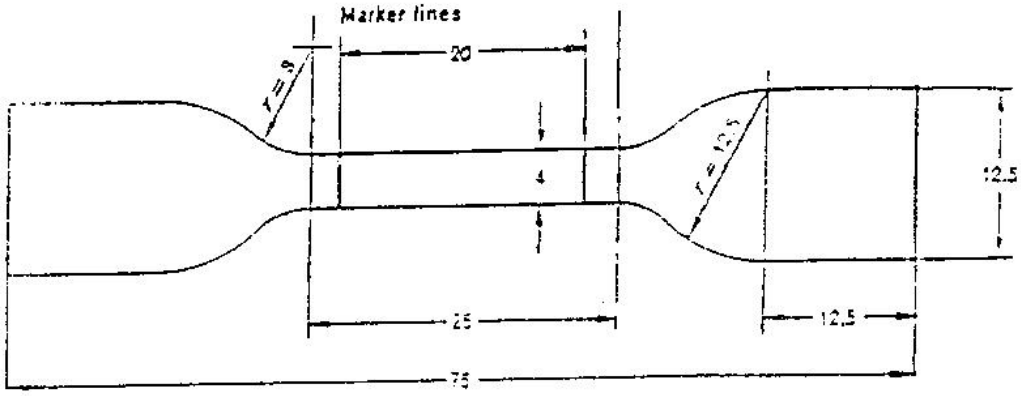

Dimensions in millimetres

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

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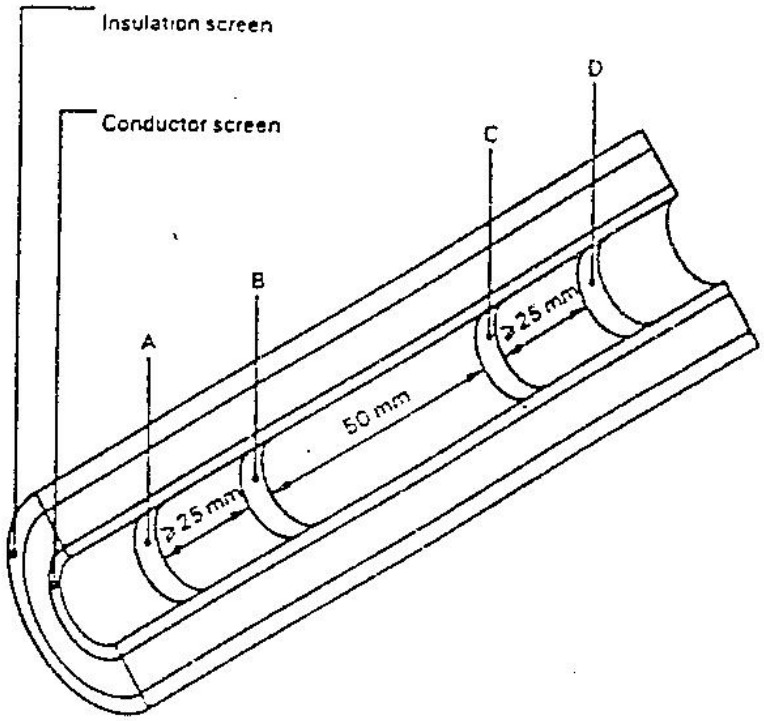

Fig (7) : Measurement of The Volume Resistivity of The Conductor Screen.

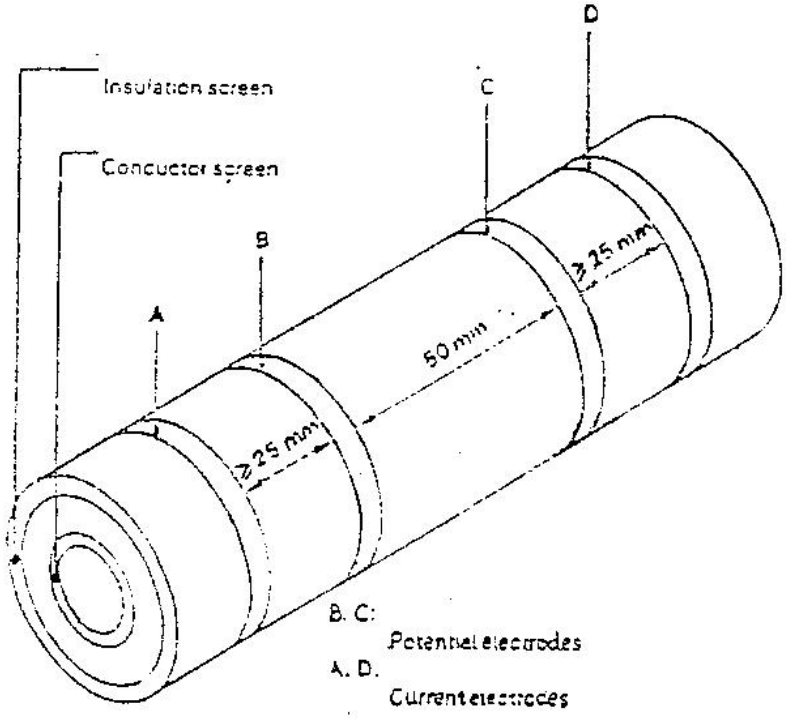

Fig (8) : Measurement of The Volume Resistivity of The Insulation Screen.

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