# CHAPTER IV.

## EQUIPMENTS, SAMPLES and METHOD of TESTING.

### A. EQUIPMENTS.

### 4.1 Artificial Rain Apparatus.

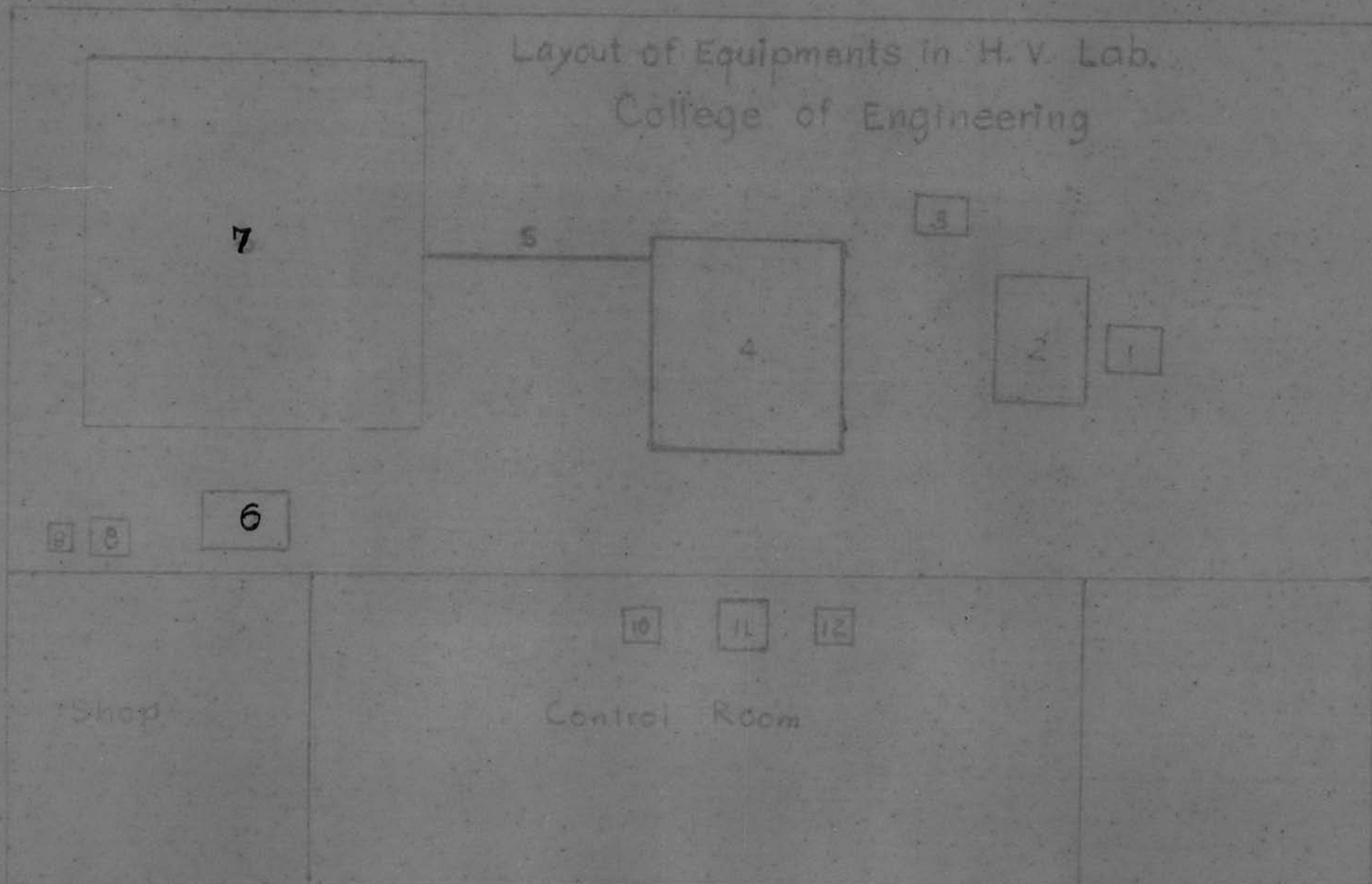
The artificial rain apparatus was constructed in the High Voltage Laboratory, the College of Engineering, Chulalongkorn University, in purpose of investigation the characteristics of insulators in wet climate. Owing to the cost of the standard artificial rain apparatus such as ASEA Rain Apparatus Type THI - MVA2 and Type MVB1 is too expensive. The price of ASEA Rain Apparatus Type YVDB is about 92,000 baths, sothat the standard rain apparatus could not be available. However the rain apparatus has been built up to give the characteristics of artificial rain satisfying to the A.I.E.E. specifications which was described in Chapter I.

#### 4.1.1 The Artificial Rain Apparatus Assembly.

The artificial rain apparatus which shown in Fig.4.1 and 4.2 consists of the main parts as following:

a) The spray apparatus.

b) The water tank with gauge of pressure and the level glass tube.


Layout of Equipments in H. V. Lab.
College of Engineering
1
2
3
4
5
6
7
8
9
10
11
12
Shop
Control Room

Description of the Layout of Equipments in the H.V.Lab.

1 220 : 200,000 V. High - Tension Transformer

2 Charging generator with selenium rectifier

3 Impulse transformer supplying the ignition impulse to the generator

4 Impulse voltage generator

5 High - Tension Line

6 Artificial Rain Apparatus

7 Space for setting up the test object

8 Water tank

9 Compressor pump and motor

10 Oscilloscope for Impulse Generator

11 Control desk of Impulse Generator

12 Tripping device to start the generator ( Impulse )

Fig. 4.1

The Artificial Rain Apparatus.

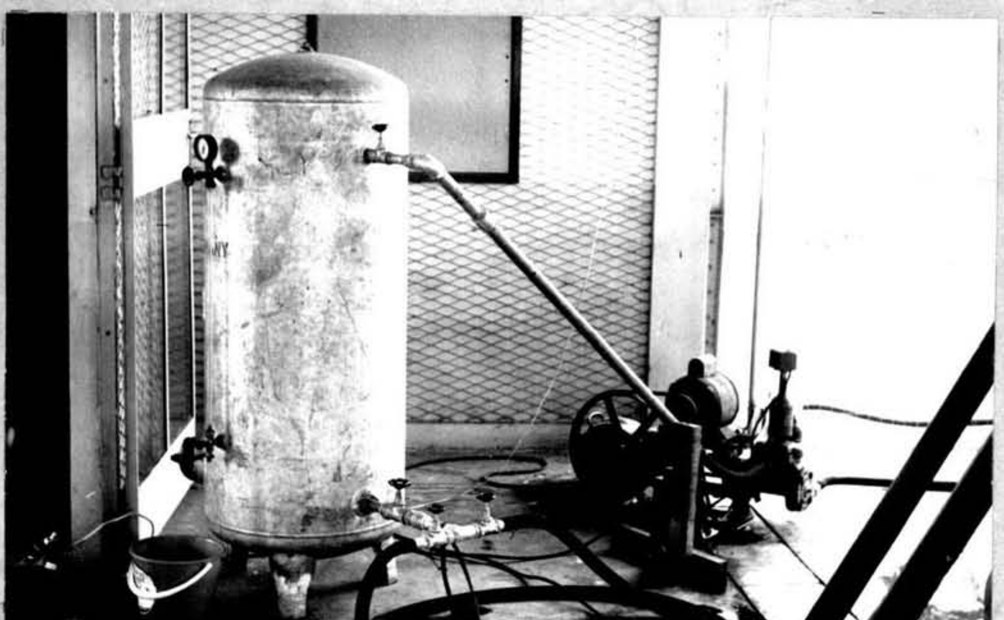


Fig. 4.2.

Compressed Motor - pump and Water tank.

c) Pressure Regulation of the water.

d) Supplied water.

### 4.1.2 Dimensions of Artificial Rain Apparatus.

a) The spray apparatus.

The spray apparatus which shown in Fig. 4.3 consists of the following:

1) Nozzle
2) Plastic tube $\frac{25}{32}$ inch. in diameter outside.
3) Brass clamp.
4) $\frac{6}{8}$ inch screw.
5) The pipe connection, the base of the nozzle.
6) Aluminium holder the nozzle.

Details of nozzle see Fig. 4.4

Outside diameter = $\frac{6}{8}$ inch.

Adjustable screw.

Hole of orifice = $\frac{3}{16}$ inch in diameter.

Plastic tube.

The plastic tube is connected the nozzle to the pipe. The plastic tube is used for purpose of flexible.

Brass clamp.

The clamp is used to fast the plastic tube with the nozzle by means of screw to protect the leakage of pressure and water at a certain pressure.

The base of nozzle.

The water pipes were connected to form the base of the nozzle as shown in Fig.4.5. The diameter of the water pipes are 1 inch and $\frac{4}{8}$ inch in diameter.

Aluminium holder.

The nozzles are supported by the aluminium sheet $\frac{1}{8}$ inch in thick and 1 inch in width.

Space of the nozzle.

The spaces between the nozzles are 15 cm. in horizontal and 20 cm. in vertical. The directions and spaces of the nozzles can be arranged by means of the flexible plastic tubes and aluminium holder.

The height of the spray apparatus.

The maximum height of the spray apparatus is 5.5 meters which support by the steel shaft on the wood ( see Fig. 4.1 and 4.3 ) construction. The height of the spray apparatus can be changed to the minimum height about 3 meters above

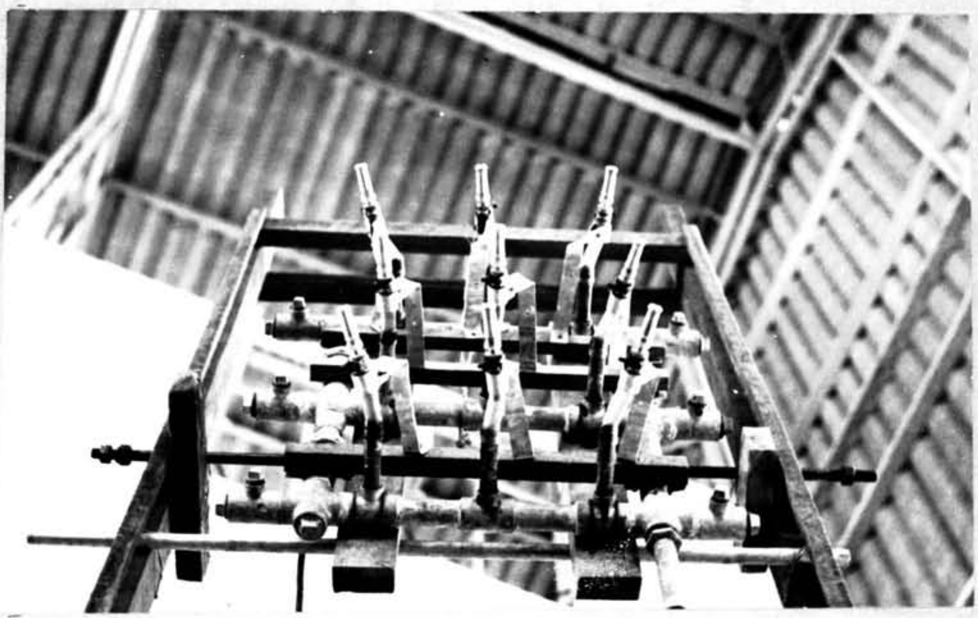
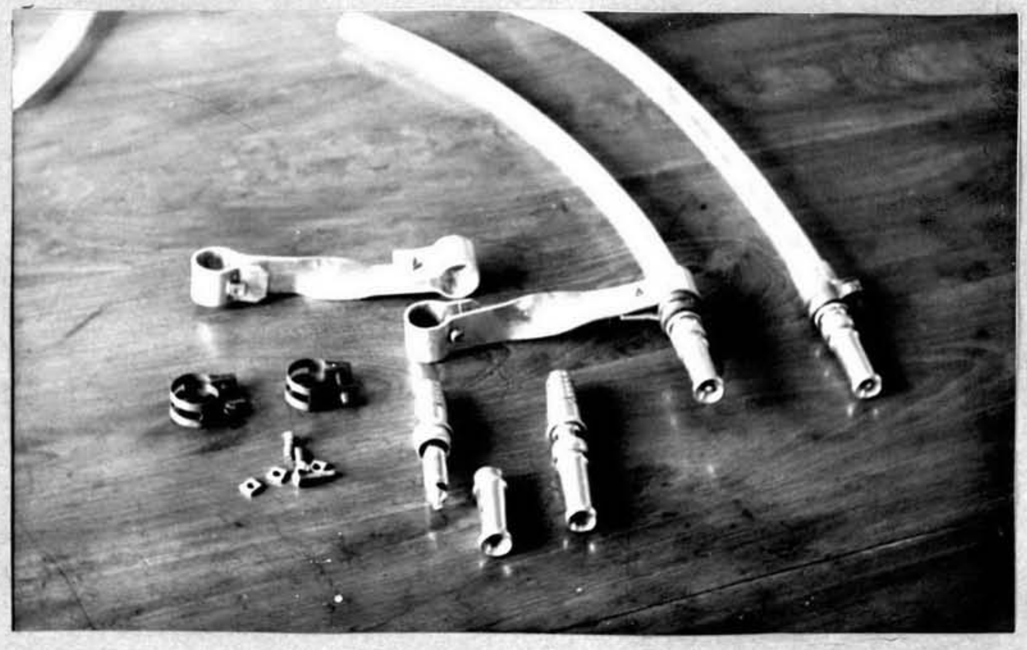


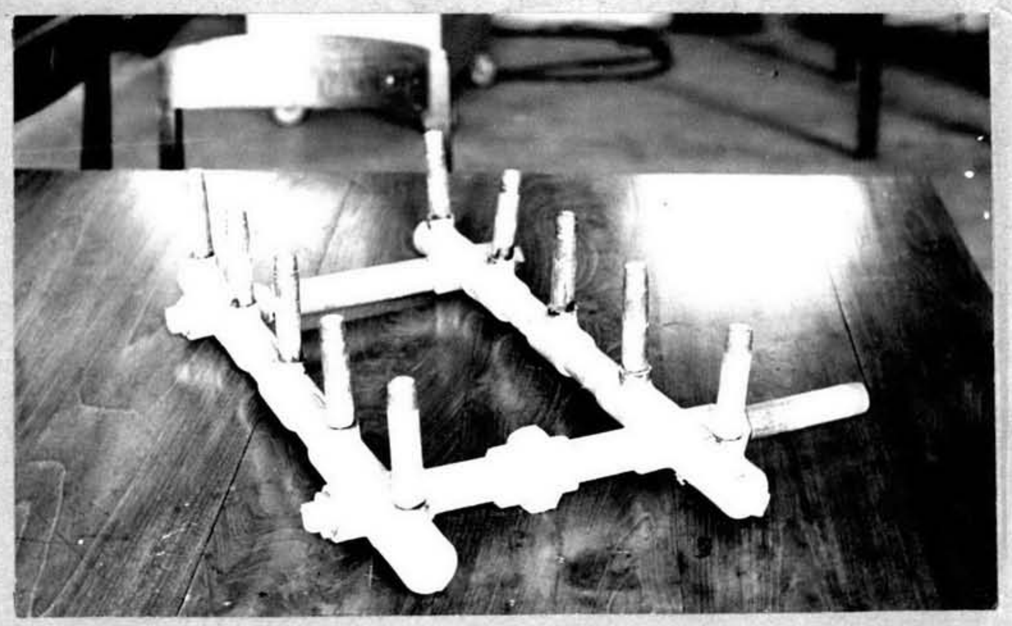
Fig. 4.3.

The spray apparatus.



Fig, 4.4.

The components of the nozzle.



Fig, 4.5.

The pipe connection to the nozzle.

the floor. The spray apparatus also can be rotated on the steel shaft, therefore the directions of the spray water are able obtained.

b) The water tank.

The water tank with pressure gauge and the level tube as shown in Fig. 4.6 has a capacity 300 litres and able work at maximum pressure about 60 pounds per square inch. The instant water in the tank can be seen at the level tube. The pressure of the water could be read from the pressure gauge in lb. per sq. in. The water is supplied through the upper valve and flows out through the lower valve.

c) Pressure Regulation.

The pressure of the water can be regulated by the compressed motor-pump as shown in Fig. 4.2. The capacity of the motor is $\frac{1}{2}$ Hp. 115/230 V. 1.6 or 3.8 Amp. 1450 rpm. The rate of flow of water can be controled by the valves and yield a certain pressure of the water. The pressure of the water could not increase more than 3 Kg. per sq.cm. because of the low capacity of the water pump. The other hand the pressure of the water depends on the amount of the water flowing out, therefore the required pressure can be adjusted by means of the outward valve (see Fig. 4.7 )

d) Supplied Water.

The two types of the water which different in resistivity were used to supply to the artificial rain apparatus. First kind of water is available from the deep-well which called the under ground water. The other kind is the water from the water supply. The resistivity of both types are much different, the former type is lower than the later type. However the proporties of the water will be described clearly in the article of artificial rain.

4.2. Characteristics of the Artificial Rain.

The artificial rain is obtained from the constructed spray apparatus as shown in Fig.4.3. The specifications of rain are described in Chapter I according to the standard which used in the U.S.A. and Europe. The characteristics of the spray in this investigation are given in the following:

4.2.1 Pressure of Water.

According to practice in U.S.A. reccomended water pressure 2.5 -4.5 Kg.per sqocm. ( 35-60 lb/sq.in. ) A water pressure between 1.5 - 6 Kg/sq,cm. is used at ASEA High Voltage Laboratory. In this investigation the water pressure is used about 2 - 3 Kg./sq.cm; because the pumping apparatus is able to regulate the pressure stability in this range.


Fig. 4.6.

Water tank with pressure gauge
and the level tube.


Fig. 4.7.

To adjust the pressure of the water by means of the valve.

A certain pressure was adjusted by means of the regulated valve.

4.2.2. Rate of Precipitation.

In general accordance with practice in a majority of laboratories the rate of precipitation of rain in vertical component is 3 ± 10 % mm/min, in Europe, 5 ± 10 % in the U.S.A. and 3 mm./min. in Sweden. In Japan the rate of precipitation 5 mm./min. is used. Generally the rate of rain-fall on the ground is 0.3 mm. to 1 mm.per minute. For this experiment in ordinary case the rate of precipitation 4 mm/min. is used, except in other definite rates are required. The rate of precipitation could be varried by the arrangment the directions and spaces of the nozzle which described clearly in article 4.1. The rate of precipitation should be measured on the side of the test object facing the nozzles and as close to the test object as is possible without collecting splashes from it. For test objects of length greater than 50 cm. measurement shall be made near the ends and the middle and values obtained for any one position shall not differ by more than 50% from the average; for tests objects of 50 cm. lenght or less the measurement shall be made near the middle only.

4.2.3. Size of Rain Drops.

The rain falls on the test object should have the form of drops and not jet. The size of drop according to the standard, is determined by the construction of the nozzles and the water pressure. In general practice the size of drops are classified in to small and large size. In this testing the exact size of rain drop is regardless. However the three sizes of rain drop were classified; includes the small, medium and large size of drops. The different size of drops are determined by visual observation. The comparable size of drops are shown in the photograph in the part of preraining test. The size of rain drop could be obtained by adjusting the orifice of the nozzle as shown in Fig. 4.8, however the size of drop is also depended on the pressure of water. At a higher pressure there will be a considerably fog drifting along with the larger rain drops. Most of this will fall down before it reaches the test object.

4.2.4. Angle of Incidence of Rain.

The most practice in testing the spray should be fall on the test object at an angle approximately $45^{\circ}$ to the vertical. The effects of varying the angle of incidence on the test object should be tested because there are many directions of rainfall. The angles could be changed by rotated the spray apparatus as described in article 4.1.2.

Fig. 4.8.

To adjust the nozzle forming the size of rain drop.

### 4.2.5. Resistivity of the Water.

The resistivity of water 10,000 ± 10% ohm-cm. is used in Europe and 17,800 ± 15% ohm-cm in the U.S.A. The resistivity of water in practice in Japan is 20,000 ohm-cm. The two types of water are supplied to the artificial rain apparatus. The water which differ in resistivity is used to observe the affect on the flashover voltage. The resistance of water changes according to the temperature. In graph sheet No. 4.1 shows the relations between the resistivity of the three types of the water to the temperature. The resistivity of water could be determined by the measurement of the resistance of water at a known of cross-section area, and a certain length. The approximate value of resistance could be measured by the ohm-meter and checked by the Wheatstone Bridge,(see Fig,4.9).

The curves show that at low temperature the resistivity of water is so high and decreased rapidly when temperature increased. The rate of decreasing of resistivity at low temperature when increase temperature is more than at high temperature. It is seen that the under ground water has too low resistivity compare to the other two types of water; especially at low temperature. The under ground water has many impurities in mixing, such as a conductive material which cause the water become a conductor. The other two types of water, water from water supply and matural rain, are almost nearly in value of resistivity. By this reason the water from the water supply is used as the artificial rain. At

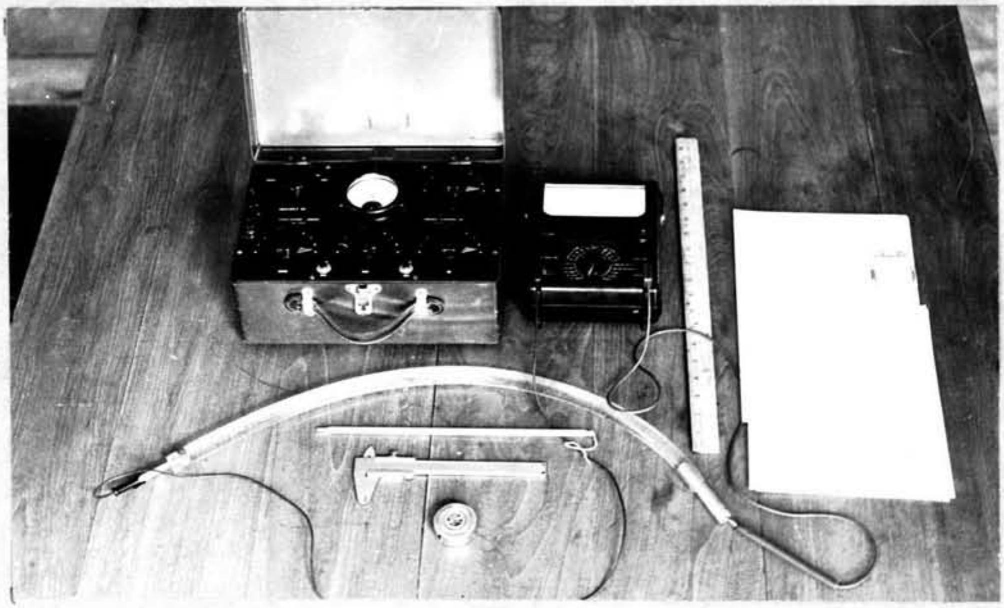
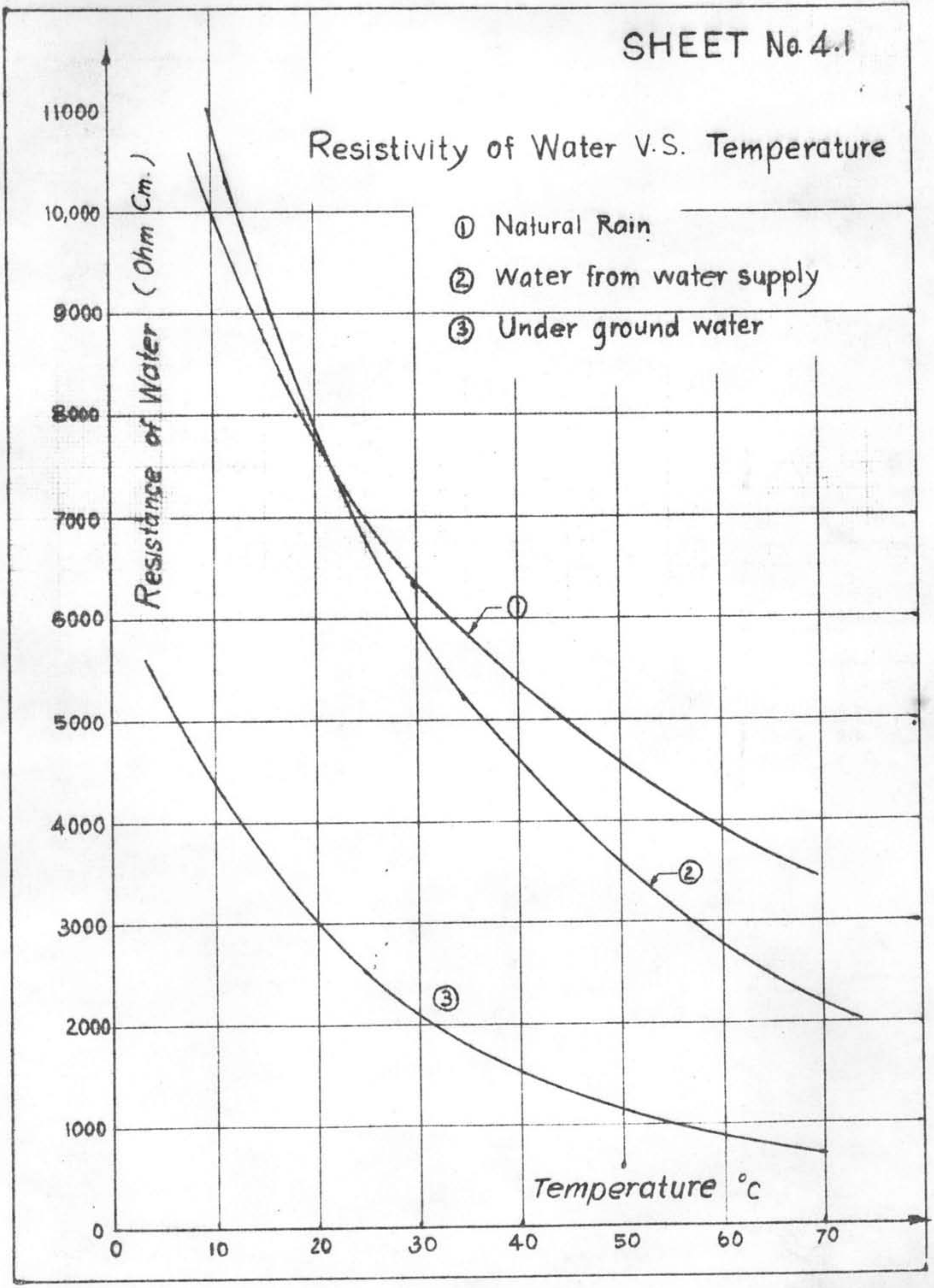


Fig. 4.9.

Measuring the resistance of the water.


SHEET No. 4.1
Resistivity of Water V.S. Temperature
① Natural Rain
② Water from water supply
③ Under ground water
Resistance of Water (Ohm Cm.)
11000
10,000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Temperature °c
0
10
20
30
40
50
60
70
①
②
③

working temperature, during testing is about $20^{o}$- $30^{o}$C.

Resistivity at $25^{o}$C = 2,500 ohm-cm. for the under ground water.

Resistivity at $25^{o}$C = 6,700 ohm-cm. for water from the water supply.

Resistivity at $25^{o}$C = 6,900 ohm-cm. for the natural rain.

## 4.3 High Voltage Supply.

The electrical equipment consisted of the following:

a) High - voltage transformer 200 KV.

b) High - voltage D.C. generator set.

c) Impulse generator set of 700 KV.

### 4.3.1 High voltage A.C.

The high voltage A.C. source is available by the 200 KVA. 220:200,000 V. High- Tension Transformer as shown in Fig. 4.10. The maximum voltage of 200 KV. as a figure should be applied, but the actual it could supply only 140 KV. as a maximum voltage. This is a limit of A.C. flashover voltage testing on insulator. The variable high voltage source could be controlled by the autotransformer.

The only high voltage A.C. source (power frequency) was supplied through the experiment.

4.3.2 High voltage D.C.

The high voltage d.c. generator set as shown in Fig. 4.11 can generate a maximum voltage 200 KV. by means of the two rectifiers (see Fig. 4.12.)

4.3.3 Impulse voltage.

The surge voltage is generated by the 700 KV. Impulse Generator as shown in Fig. 4.13 which is composed of a charging generator of 200 KV, a basic impulse generator and a control desk. A standard impulse wave form could be adjusted by the high voltage discharge resistors and capacitors immerse in oil (see Fig. 4.14 )

4.4 Measuring Instruments.

The measuring instruments consists of the following:

1) Sphere gap 12.5 cm. diameter.

2) A.C. voltmeter 0 - 250 V.

3) D.C. Kilovolt meter 0 - 200KV.

4) A.C. ammeter 0 - 30 Amp.

5 ) High - speed cathode ray oscilloscope.

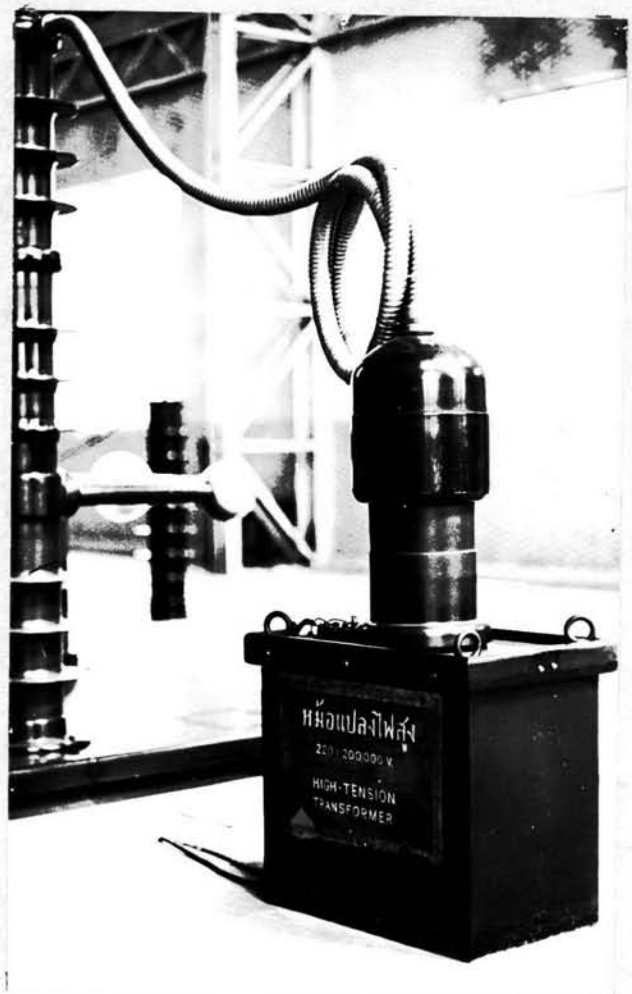



Fig. 4.10

200 KV. High - Tension Transformer.

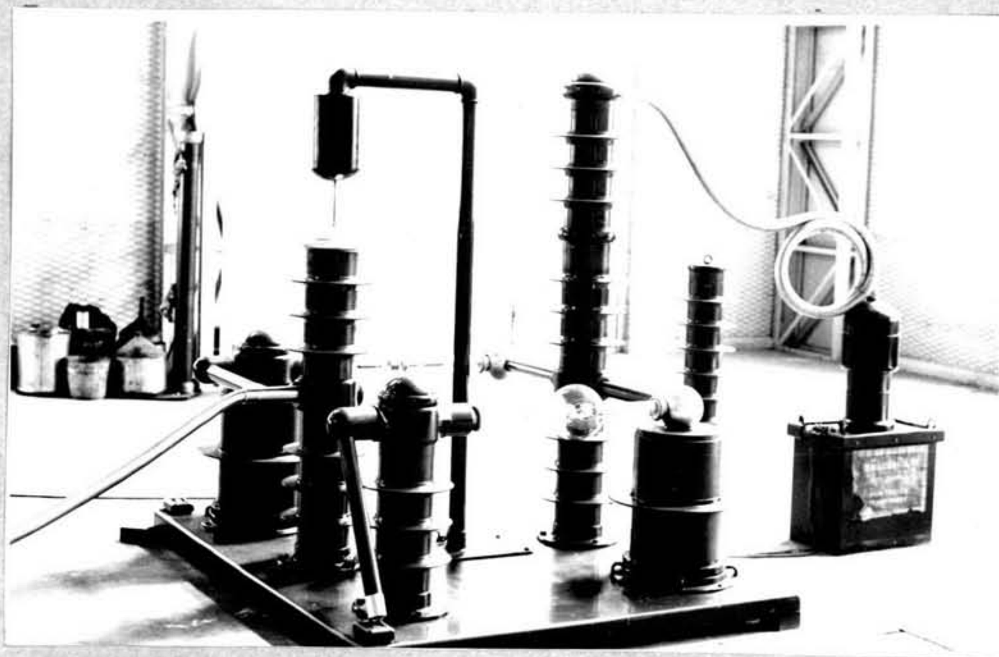


Fig. 4.11

High Voltage D.C. Generator Set

and Earthing Rod.



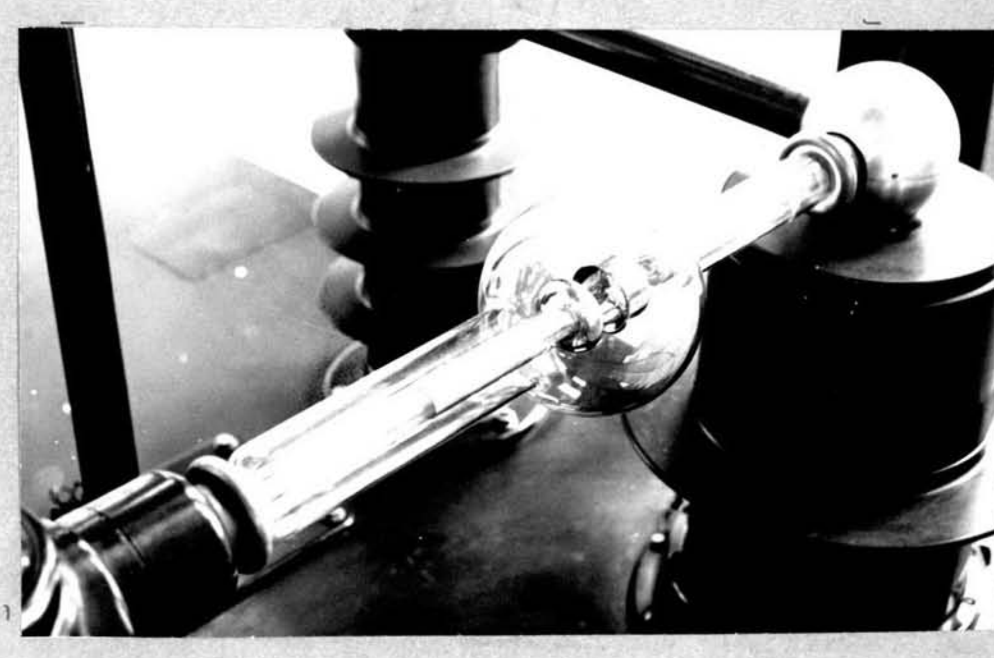


Fig. 4.12

Rectifier.

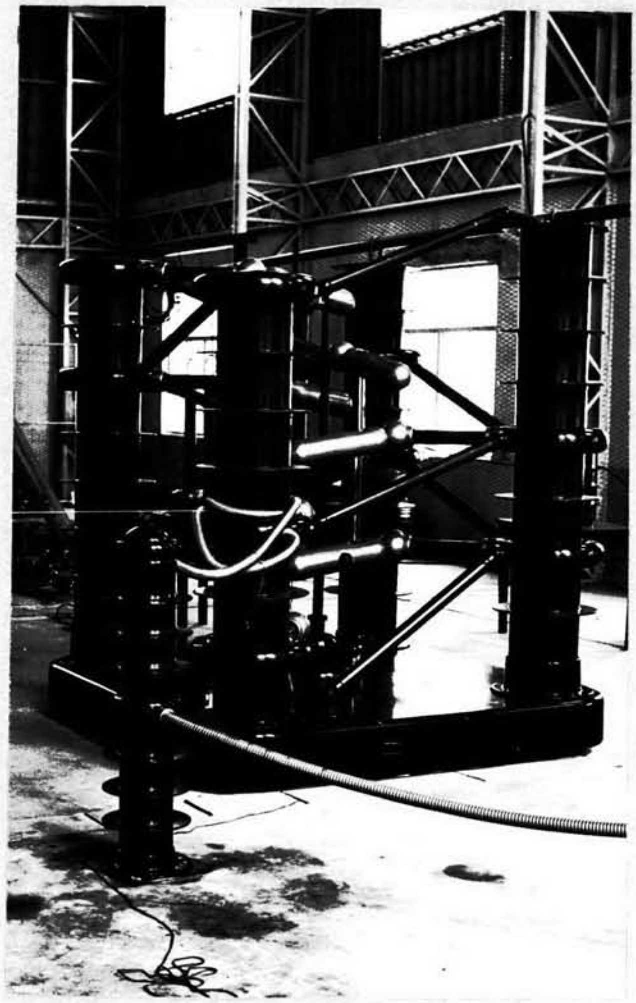


Fig. 4.13.

The 700 KV. Impulse Generator.

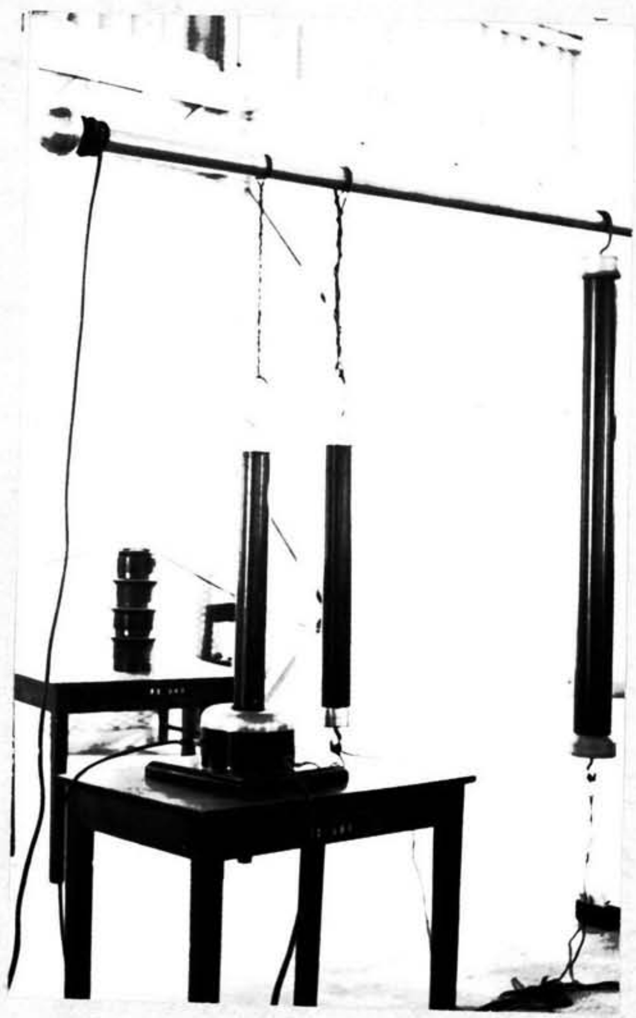


Fig.4.14.

High Voltage Resistors and Capacitor to form the 1 : 50 Impulse wave - form.

Standard Sphere Gap.

The sphere gap is a reliable instrument to measure a high - voltage, because it frees from errors due to corona effects within the instrument, and to external extrostatic fields. The value of the potential difference required for spark over depends upon the electric strength of air, the size of the spheres, their distance apart, and upon a number of other factors. The disadvantage of the sphere - gap method of measurement is that it cannot be used to give a continuous record of voltage. It is generally used to calibrate some indicating instrument, or other apparatus. which does give such a continuous record. The sphere gap which available in the High Voltage Laboratory, College of Engineering, C.U. is 12.5 cm. diameter. ( see Fig. 4.15.)

A.C. Voltmeter.

A 0-250 V. a.c. voltmeter is attached at the panel of the control desk as shown in Fig. 4.16 . It is a absolute instruments depend upon a direct measurement of the forces which produce by the applied voltage. This is the direct method of measuring voltage, and the actual voltage can be obtained from reading immediately. The advantage of this method is that it can be used to give continuous record of voltage.

Usually this voltmeter is used to indicate the applied

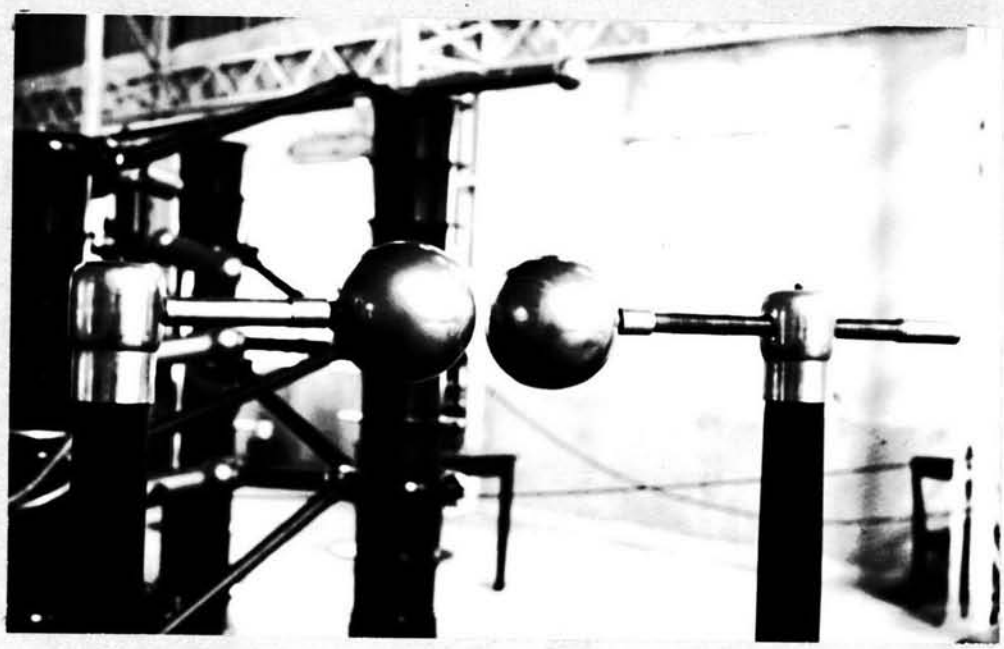


Fig. 4.15.

Sphere gap 12.5 cm. diameter.

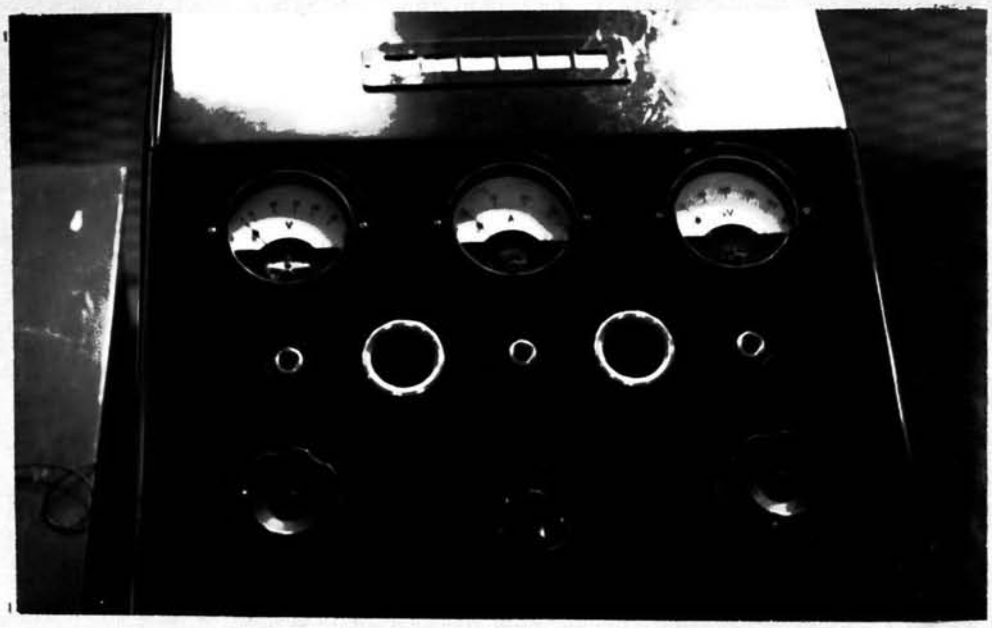


Fig. 4.16.

The Panel of the Control Desk.

voltage to the primary or low side of the 200 KV. High-Tension Transformer. According to the measurement of a high voltage by this voltmeter, it was necessary to be calibrated in order to indicate the voltage on the high side of the transformer by means of the 12.5 cm. diameter sphere gap which shown in the appendix.

D.C. Kilovolt Meter.

The kilovolt meter has the range between zero to 200 KV. maximum. Actually this meter is a 200 micro ammeter. It is calibrated to indicate the d.c. voltage which apply to the surge impulse generator; therefore the various voltages of d.c. can be read directly from the panel KV. meter

A.C. Ammeter.

This meter is attached on the panel of the control desk, having a range 0 - 30 amp. It is used to measure directly current on the low side or the otherward it indicate the applied current to the primary of transformer.

A high - speed cathode ray oscilloscope (see Fig.4.17) is an apparatus to record the impulse voltage wave form and may be used to determined the magnitude of surge voltage.

Fig. 4.17.

High - Speed Oscilloscope.

## B. SAMPLES.

### 4.5 Sample of Insulators for Testing.

Only six types of insulator as shown in Fig.4.18 were used in the test. These are the NGK insulators which produced by the Nippon Gaishi Kaisha Ltd., Nagoya in Japan. They were selected to be the samples of testing because the most of insulators which using in the high tension power system in Thailand are manufactured by the above company. It is hoped that the selection of these types of insulator will in no way prejudice the possibilities of other types.

The sample of insulators may be classified into two groups as the following:

a) High voltage pin type insulator.

b) Suspension type insulator.

#### 4.5.1 Pin type Insulators.

This type includes 3 kinds in testing.

a) A small size of pin insulator is denoted by the symbol P-1 which having a dimension $4\frac{3}{4}$D x $5\frac{1}{8}$ inch as shown in Fig. 4.19.

b) The medium size of pin insulators are denoted by P-2.1 having a dimensions $6\frac{1}{2}$D x $4\frac{3}{4}$ inch and $5\frac{1}{2}$ D x $5\frac{1}{8}$ respectively (see Fig.4.20 )

Fig. 4.18

Six types of the Sample Insulators.

Fig. 4.19.

High Voltage Pin type insulator P-1

BP - 73, $4 \frac{3}{4}" \times 5 \frac{1}{8}"$

Fig, 4.20.

High Voltage Pin type insulator P-2 and P-2.1

AP - 182 6 $\frac{1}{2}$" x 4 $\frac{3}{4}$" , AA168N 5 $\frac{1}{2}$" x 5 $\frac{1}{8}$"

Fig. 4.21.

High - Voltage Pin type insulator P - 3

AP - 273 , EEI - NEMA Class 56 - 2.

9"D x 6 $\frac{1}{2}$"

Fig. 4.22.

Small Suspension insulator S -1

CA - 15923A, EEI - NEMA Class 52 - 1

6" D x 5 $\frac{1}{2}$"

Fig. 4.23.

Medium Suspension insulator S - 2.

CA 564 GC 178 mm,D x 110 mm.

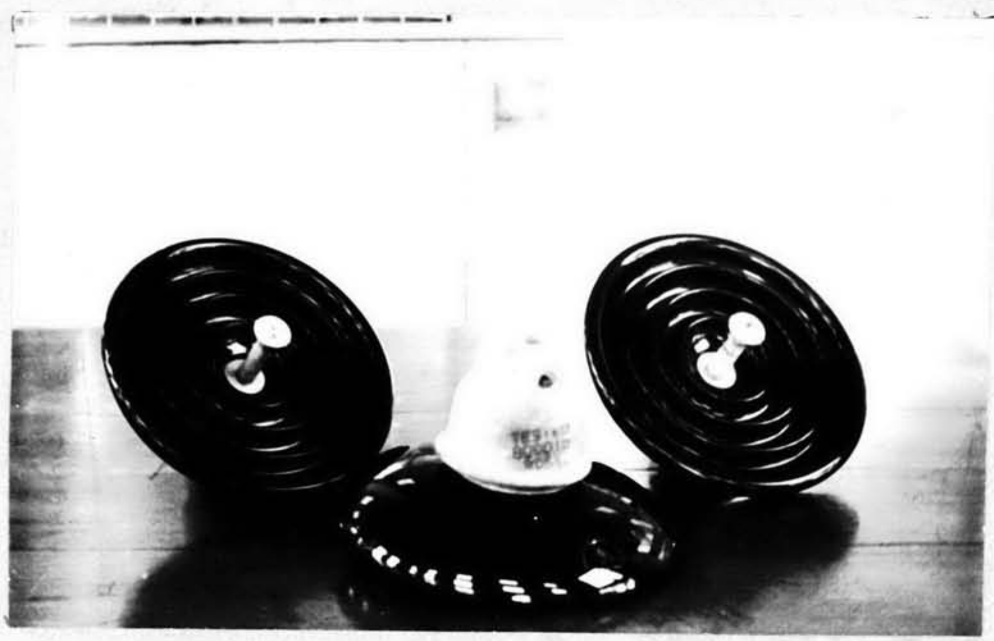


Fig. 4.24.

Large Suspension insulator S - 3.

CA 525 MR, EEI - NEMA Class 52 - 5.

10" D. x 5 $\frac{3}{4}$"

c) A large size of pin insulator is denoted by P - 3 which having a dimensions 9" D x 6 $\frac{1}{2}$ ( see Fig. 4.21 ). This kind is named by the EEI - NEMA, Class 56 -2.

4.5.2. Suspension type Insulator.

The suspension type insulator may be divided into 3 kinds corresponding to their size as following.

a) A small size of suspension insulator is denoted by S - 1 which called Class 52 - 1 by the EEI - NEMA ; see Fig 4.22. It has a dimension 6"D x 5 $\frac{1}{2}$".

b) A medium size of suspension insulator is denoted by S- 2 which having a diamension 178 mm. dia. x 110 mm.

c) Large suspension insulator is denoted by S - 3 which called 52 - 5 by the EEI - NEMA see Fig 4.24. It has a dimension 10" D x 5 $\frac{3}{4}$" .

However the characteristics of these insulators which specified by the Nippon Gaishi Kaisha Ltd. were shown in the Technical Particular Specifications.

Technical Particulars*

For High-Voltage Pin type Insulators

| | | BP-73 P-1 | AP-182 P-2 | AA-168N P-2.1 | AP-273 P-3 |
|---|---|---|---|---|---|
| Working Voltage | KV. | 6 | 11 | 11 | 22 |
| Flashover Voltage | | | | | |
| Power Frequency | | | | | |
| Dry | KV. | 70 | 80 | 80 | 110 |
| Wet | KV. | 45 | 48 | 50 | 70 |
| Impulse $1 \times 50 \mu S$. | | | | | |
| Positive | KV. | 100 | 115 | 125 | 160 |
| Puncture Voltage | KV. | 80 | 120 | 150 | 230 |
| Leakage distance | ins. | $8\frac{5}{8}$ | $7\frac{1}{2}$ | 10 | $16\frac{1}{2}$ |
| Breaking Strength | lbs. | 1500 | 2600 | 2600 | 2400 |

* BP-73, NGK Insulator
Nippon Gaishi Kaisha Ltd. Nagoya,
Japan Catalogue No. 55 p. 70

AP-182 Ibid p. 80

AA-168 Ibid p. 83

AP-273 Ibid p. 81

Technical Particulars*

For Suspension type Insulators

| | CA-15923A S-1 6×5 1/2 | CA-565MR S-2 7 1/2×5 3/4 | CA-525MR S-3 10×5 3/4 |
|---|---|---|---|
| Leakage Distance ins | 7 | 8 1/4 | 11 |
| Flashorer Voltage | | | |
| Power Frequency | | | |
| Dry KV | 60 | 65 | 80 |
| Wet KV | 30 | 35 | 50 |
| Impulse, 1×50μS Pov.KV | 100 | 115 | 125 |
| Puncture Voltage | 110 | 125 | 140 |
| Dry Arcing Distance in | 4 1/2 | 5 3/4 | 7 3/4 |

* NGK Insulator, Nippon Gaishi Kaisha Ltd.
Nagoya, Japan Catslogue No. 60 p. 90
CA-565MR, CA-525 p. 90
CA-15923A, Ibid p. 92

## C. METHOD of TESTING.

### 4.6 General Arrangement of the Test Object.

The clearance to the extraneous structures and the general disposition of the test object, such as its height above ground level, arrangement, of high voltage leads, are important on the effect of the flashover characteristics of the test object. Special requirements specified by the ASA. ( American Standards Association ) which concerning with this testing will be shown as following.

#### 4.6.1 Suspension Insulator Mounting Arrangement.

The test speciment ( unit or string ) shall be suspended vertically at the end of a grounded conductor so that the vertical distance from the upper most point of the insulator hard ware to the supporting structure shall be not less than 3 feet.

No objects, other than parts of the test assembly , shall be nearer the test specimen or energized electrodes than $1\frac{1}{2}$ times the test specimen dry arcing distance, with a minimum allowable distance of 3 feet.

4.6.2 Pin Insulator Mounting Arrangement.

The supporting cross arm shall be a horizontal, straight, smooth, grounded, metallic tube or structural member having a horizontal width not less than 3 inches nor more than 6 inches, It shall be of such length that flashover will not be initiated at its ends. The proximity of other objects, are the same as a suspension's clearance.

4.7 Dry Tests.

The test sample shall, before the test, undergo the conditioning process specified in the appropriate recommendations ( treatment in vacuum, thermal treatment, etc.) and shall be tested at the prescribed temperature. If not otherwise stated, the test shall be made at ambient temperature and the test object shall be dry and clean.

4.7.1 Voltage Application.

The initial applied voltage may be quickly raised to approximately 75 percent of the expected average dry flashover voltage value. The continued rate of voltage increase shall be such that the time to flashover will not be less than 5 seconds or more than 30 seconds after 75 percent of the flashover value is reached.

### 4.7.2 Dry Flashover Voltage Value.

The dry flashover voltage value of a test specimen shall be the arithmatic mean of not less than 5 individual flashovers taken consecutively. The period between consecutive flashovers shall be not less than 15 seconds nor nore than 5 minutes.

## 4.8 Wet Tests.

Generally it is recognized that wet tests are not intended to reproduce actual operating conditions but to provide a criterion based on accumulated experience that satisfactory service operation will be obtained.

### 4.8.1 Voltage Application.

At not less than 1 minute after the final adjustment of the spray, the applied voltage may be raised quickly to approximately 75 percent of the expect average wet flashover voltage value. The continued rate of voltage increase shall be such that the time to flashover will be not less that 5 seconds nor more than 30 seconds after 75 percent of the wet flashover voltage value is reached.

### 4.8.2 Wet Flashover Voltage Value.

It is determined by the same method as dry flashover value as described in 4.7.2

4.9 Test Procedure.

The test sampled insulator was arranged as described in article 4.6 ( General arrangement of the test object. )

The characteristics of insulators are investigated as the following.

4.9.1 Dry Flashover Testing.

The testing was made at ambient temperature and was cleaned before applied voltage. The method of applying voltage and flashover voltage value were described clearly in Article 4.7. A dry flashover testing used the following insulators:

a) Pin type, includes P - 1, P - 2, P - 2.1 and P - 3

b) Suspension type includes S - 1 and S - 2.

4.9.2 Wet Flashover Testing

The artificial rain was obtained from the constructed spray apparatus ( see Fig. 4.25 ). Usually, if not specified a certain condition the water pressure undertesting would be 2.5 Kg.per sq.cm. The rain drops should fall at about $45^{o}$ angle on to the test object. Precipitation generally was rated at 4 mm. per minute. The resistivity of water was explained clearly in article 4.2. The characteristics of insulators under wet test were investigated as the following conditions.

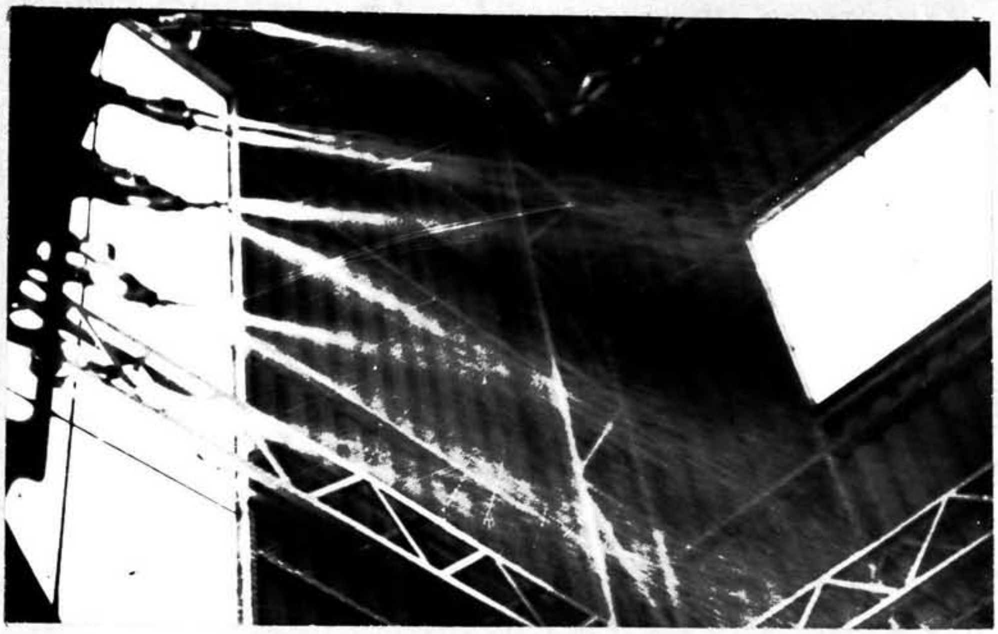


Fig. 4.25.

Rain from the rain apparatus,
water pressure about 2.5 kg/cm.²

a. <u>Wet Flashover Testing on Insulator as a function of time preraining ( short time test )</u>.

The effect of time preraining of the insulator before the voltage is applied was carried out. The sampled insulators for this experiment included insulator type P - 1, P - 2, P - 2.1, P - 3, and S - 3.

The effect of time preraining was tested under different size of rain drops, i.e. medium and small, so that the results under both conditions should be compared. For this purpose of find out the artificial rain from the under ground water was supplied.

b. <u>Wet Flashover Testing at difference of time interval applied</u>.

According to the specification of ASA the period between consecutive flashovers shall be not less than 15 seconds, nor more than 5 minutes. The flashover voltage value at period applied 12 second and 60 second were carried out.

c. <u>Wet Flashover Testing ( short time test ) at Different Size of Rain Drops</u>.

Three sizes of rain drops were performed for this purpose included small, medium and large size. The sampled insulators for this testing were P - 2, P - 2.1, P - 3 and

S - 3. Each type of insulators consists of 6 units to be sample in testing.

The time of preraining on insulator before the voltage was applied should not less than 5 minutes.

In Fig 4.25.1 shows that the pin insulator type P - 3 to be preraining with large size of rain drop. Fig 4. 26 is a string of 6 suspension insulators type S - 3 under preraining with medium size of rain drops. Fig. 4.27. a string of 7 suspension insulators type S - 2 was under raining with large size of rain drops. A small size of rain drops, falling on the pin insulators type P - 3 in parallel was shown in Fig. 4.28.

The rate of precipitation should be measured as shown in Fig. 4.29. before the voltage was applied. For this experiment the rate of precipitation was about 4 mm./min. and the pressure of water was kept constant at 25 Kg. per sq.Cm. The angle of rain falling on the sample was about 45 degree.

Every unit of sample insulator was repeated of performing about 15 times.

d. <u>Wet Flashover Testing ( short time test ) on Insulator at Various Rate of Precipitation</u>.

The effect of variation on rate precipitation was carried out by using the pin insulator type P - 3 to be a sample of investigation. The rate of precipitation included

Fig. 4.25.1

Preraining on the pin type P - 3.

with large size of rain drop.

Fig. 4.26.

Preraining on string suspension insulator type S - 3 with medium size of rain drop.

Fig. 4.27.

Preraining on string of suspension insulator type S - 2 with large size of rain drops.

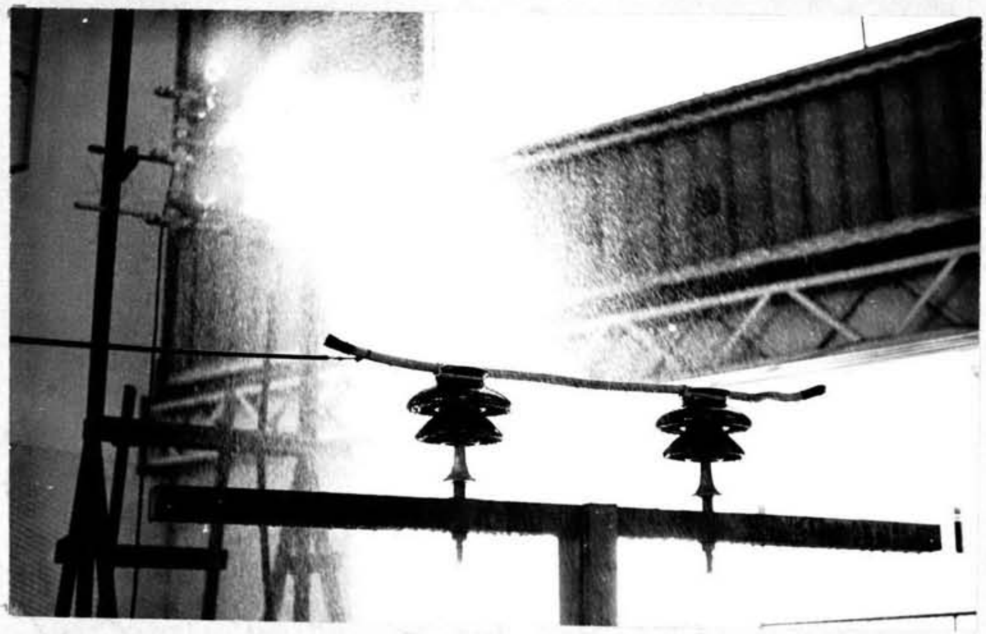


Fig. 4. 28.

Preraining on the pin type P - 3 in parallel with small size of rain drop.

Fig. 4.29.

Measuring the rate of precipitation of the rain.

1,2,3,5,7.5,10, and 15 mm. per minute. Each rate of precipitation three units of sample were tested; and 15 reading for each unit was taken. Note that the rate of precipitation of rain could be varied by adjusting the direction of nozzles.

e. Wet Flashover Testing (short time test ) at Different angle of Inclination.

Generally the characteristics of insulators in wet test, the rain falls as drops at about 45 degrees angle on to the tested object. The other angle of falling should be investigated. Both small and medium size of rain drops are performed for this purpose on pin insulator type P - 3 ( see Fig. 4.30 )

f. Wet Flashover Testing ( short time test ) at Different Resistivity of Water.

The effect of resistivity of water on flashover voltage was carried out according to the difference of water, i.e. the under ground water and water supply. The sample of insulator was S - 3, and 15 readings were taken.

g. Potential Distribution under Wet Test.

The potential distribution on a string of suspension insulators type S - 1, S - 2 and S - 3 were tested in a vertical position. The rate of precipitation were measured

Fig. 4.30.

Pin type insulator P - 3 at position $45^{\circ}$ inclination.

at both the ends and the middle of the string and average about 4 mm./ min. By this testing the efficiencies of string insulator could be determined ( see Fig. 4.31.)

h. Wet Flashover Voltage ( short time test ) on Pin Insulator Type P - 3 in Parallel.

In order to observe the flashover voltage on pin insulator in parallel, the two units of pin insulator type P - 3 were arranged as shown in Fig. 4.28 )

4.9.3 Phenomena of Wet Flashover on Insulators.

The flashover should be occured at a shortest arcing distance. Under wet conditions the arcing distance are shorter than a dry condition, so that the wet flashover would be started on the side of insulator which had the most wet surface. The observation on wet flashovers were shown by the photographs, as following.

Fig. 4.32 was the flashover on a pin insulator type P - 2.1.

Fig. 4.33 (a) and (b) were the flashover on the pin insulators type P - 3 at a vertical position.

Fig. 4.34, and Fig. 4.35 (a), (b) were the flashover on pin insulators type P - 3 at 45 degree angle with the vertical.

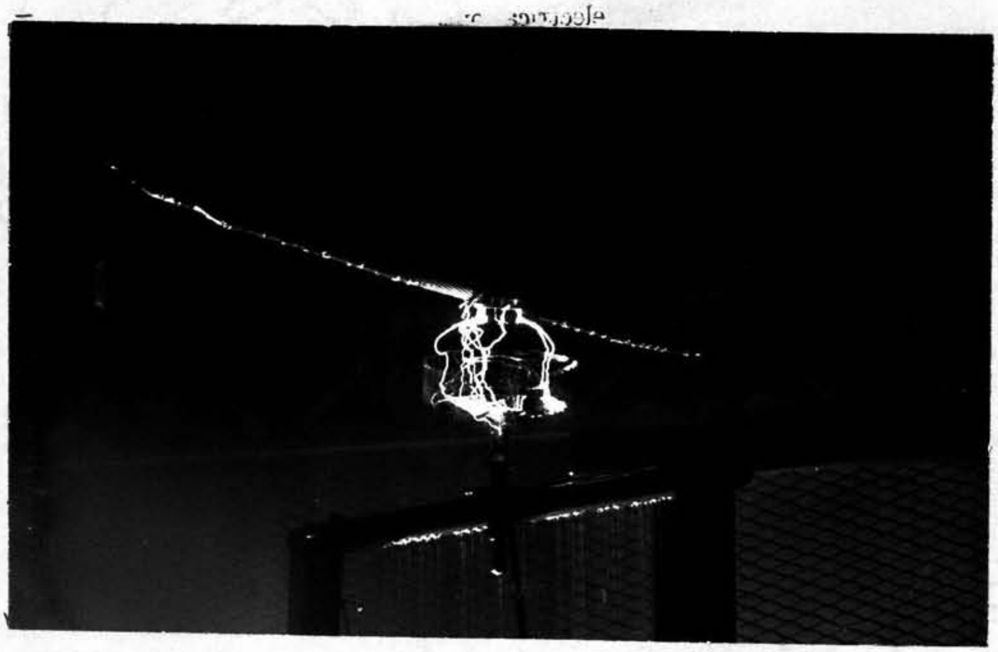
Fig. 4.36. and Fig. 4.37. were the flashover on the string of suspension insulators type S - 3 .

Fig. 4.31.

Operating on String of Suspension Insulators.

Fig. 4.32.

Flashover on Pin insulator type P - 2.1.



(a)

(b)

Fig. 4.33.

Flashover on Pin insulator type P - 3 at vertical position.

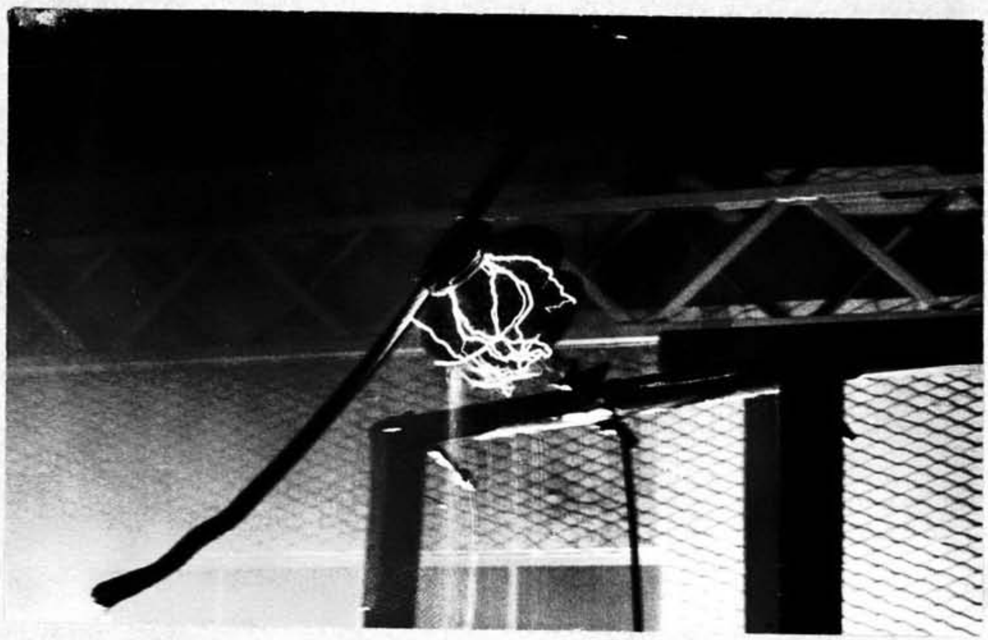
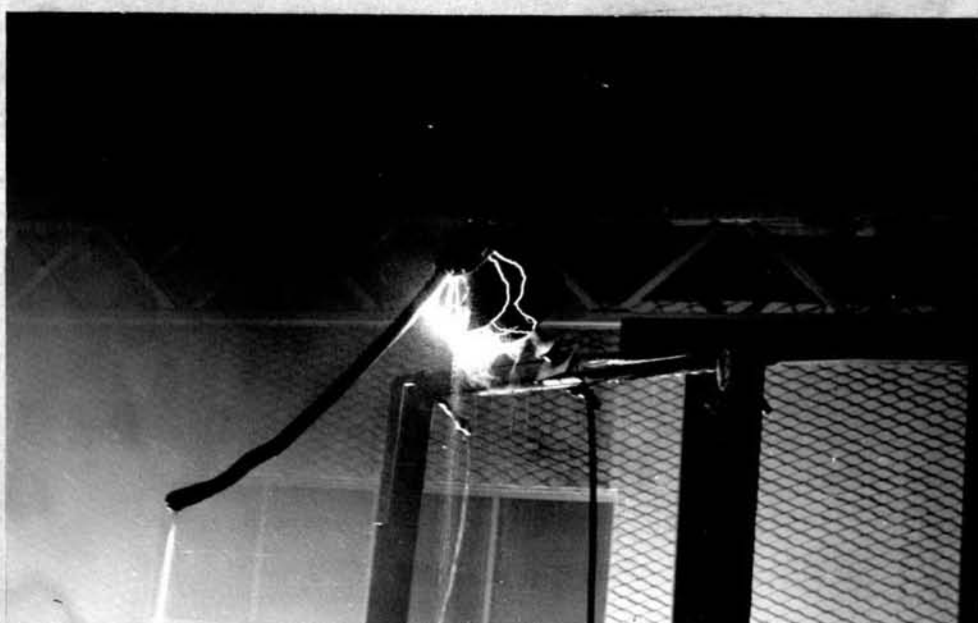


Fig. 4.34.

Flashover on Pin insulator type P - 3.

(a)



(b)

Fig. 4.35.

Flashover on Pin insulators type P-3.

at 45 degrees inclination.

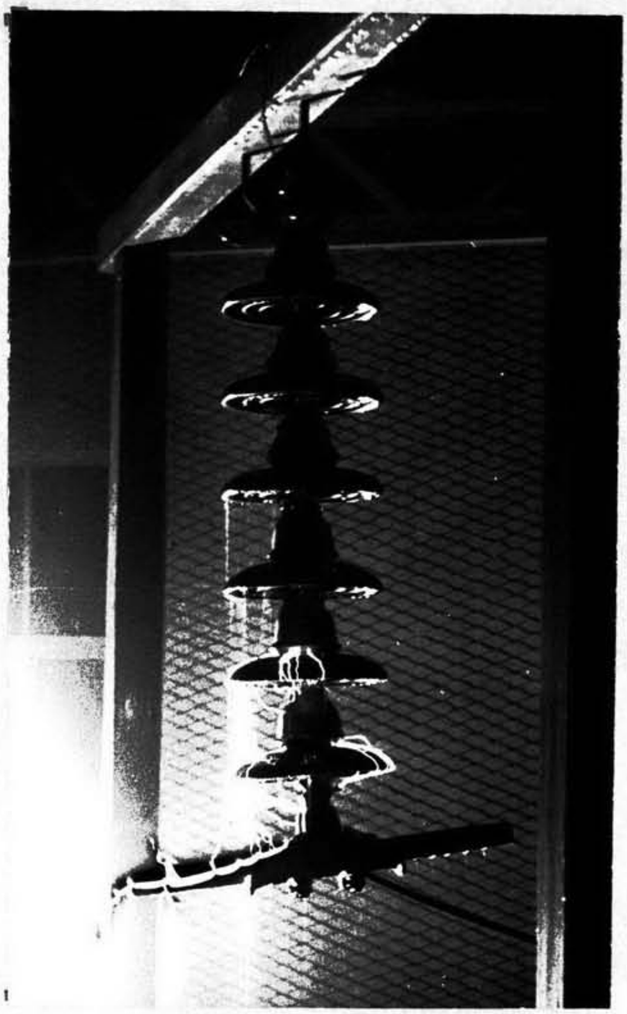


Fig. 4.36.

Flashover on String (2 unit) of Suspension insulator type S - 3 .

Fig. 4.37.

Flashover on String of Suspension insulator type S - 3.