FACTORS AFFECTING CORONA CHARACTERISTICS OF THIN WIRES

BY

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ABSTRACT

The present work describes an expermental study of corona characteristics performed on single conductors under different parameters. The actual different modes of corona were analyzed as they appear in wire to plane configuration for wire diameter ranging from 0.3 to 2mm and for gap lengthes up to 8 cm. Measurments are made to show the effect of circuit resistance on critical corona voltages of thin wires. The circuit resistance is varied from 5 to 15 M ohm. For positive corona it is observed, that the circuit resistance makes burst pulse or onset streamer appear t the same time with glow corona. On the other hand the steel, copper and aluminium materials are used-as an example-showing the effect of different material on several corona modes, under A.C voltage and D.C. voltage of both polarities. Critical corona voltages are greatly affected by weather conditions and tend to decrease as the relative humidity increases and the decreasing in critical corona voltage is more higher in the case of moistened pollution conditions.

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INTRODUCTION

In power transmission engineering, corona discharge occurs on conductors, hardware and insulators as a field-sustained electrical breakdown of air. This breakdown produces visible light, audible noise, energy loss, radio interference, chemical action and mechanical vibrations . Since all these effects are undesirable, corona has been the subject of intensive studies. Corona appearance depends upon many parameters which have been subjected to extensive investigations by engineers and physists. Corona discharge in air takes several distinctive forms either pulsative or stable depending upon some parameters such as electrode protrusions, wire diameter, circuit resistance at mospheric weather conditions (such as fine, cloudy, rain, snow, fog), pollution and humidity.

EXPERIMENTAL SET-UP

The corona appartus consists of a wire-plane arrangement. The high voltage electrodes consist of a smooth metal wire hanged to a cylinderical brass electrode of 15 cm length and 2 cm diameter. The hanged end of the electrode is shaped in a circular form. This was done to eliminate the end effect of the wire. Wires with diameters of 0.3, 0.8, 1, 1.1, 1.25 and 2 mm are investigated. Wires less than 1.6 mm diameter will be referred to in this work as thin wires while those greater than 1.6 mm will be considered as thick wires. The gap length is varied from Zero to 8 cm. The wires are cleaned and degreased before any test. The other electrode is an a luminium disc of 25 cm diameter with round edges and is earthed through a resistance for oscilloscopic observations. The high voltage from the transformer or rectifier is applied to the wire electrode through a resistance consisting of a chain of carbon resistors. The circuit resistances have values of 5.10 and 15 M ohm.

RESULTS AND DISCUSSIONS:

(1) Effect of wire diameter.

The theoretically equation ofcritical corona voltages shows that the critical corona voltage depends upon the wire diameter. The stranding of the conductors decreases the effective radius and causes an enhancement of the field and hence a reduction in the critical voltage. The effect of wire radius is carefully investigated for different corona modes.

Fig (1) shows the dependence of visual corona voltage on the gap distance for different conductor diameters. It is clearly seen that this voltage depends strongly on the conductor diameter. As an example, a copper conductor of 0.3 mm diameter has a visual corona voltage of 3 K.V at 2 cm gap distance increases to 18 K.V as the gap distance is increased to 7 cm. The visual corona voltage increases by the increasing of conductor diameter, for the same gap distance. For the mentioned gap distances this voltage has the values of 5.5 and 21 K.V for wire diameter 0.8 mm increases to 12.5 K.V and 27 K.V as the wire diameter is raised to 1.25 mm. It is also seen that for the same gap distance the glow onset voltage is higher for thick wires than that for thin wires. The different modes of corona are carefully investigated visually and by means of oscilloscope. Many current oscilloscope traces have been recorded during all tests only some few traces are given here as comparative examples. As the applied voltage across the gap is gradually increased, unstable irregular luminous dots are observed wandering along the wire. This mode of corona is known as burst pulse corona. Figure (2) shows the oscilloscope current traces of these pulses for gap distance 4 cm and different wire diameters namely 0.8 mm and 1.25 mm shown by photos a and b respectively. It is clearly seen that the burst pulses voltage increases as the wire diameter is increased.

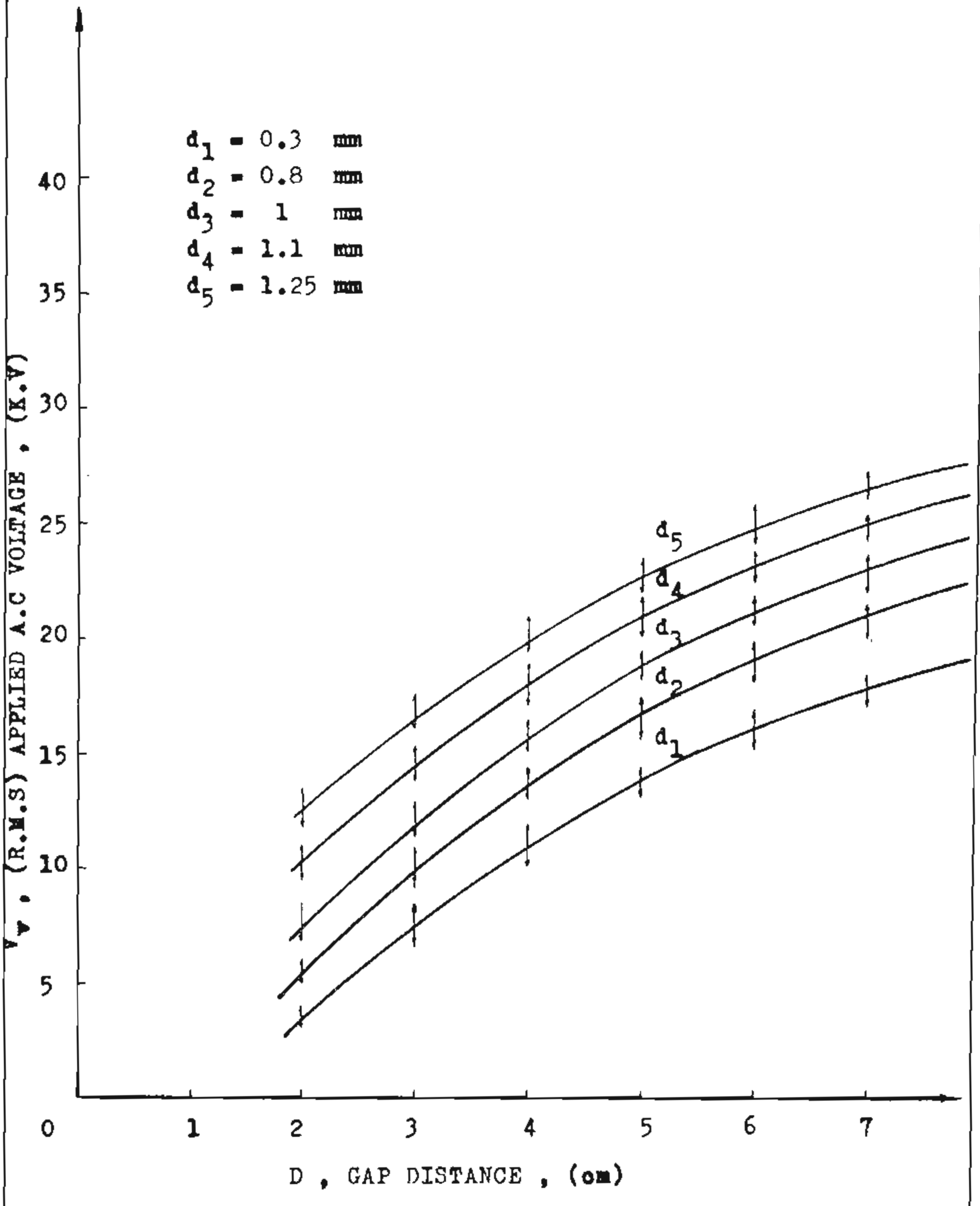
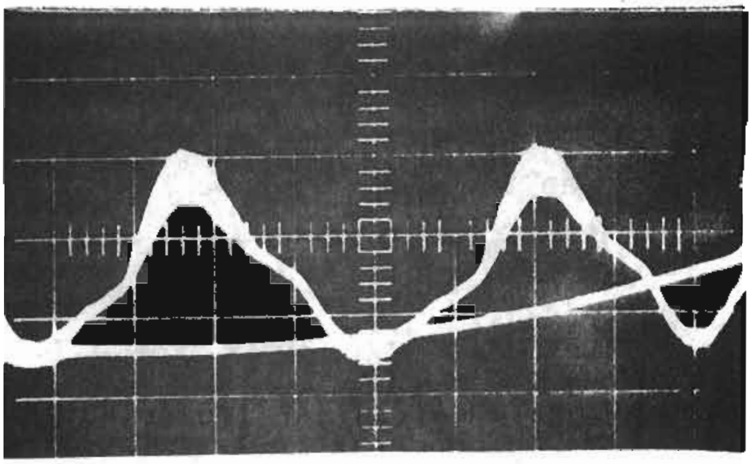
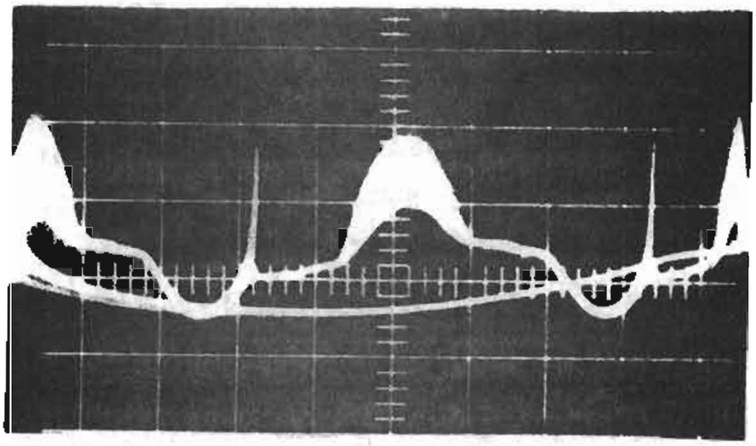


FIG.(1) THE DEPENDENCE OF THE GLOW ONSET VOLTAGE FOR DIFFERENT CONDUCTOR DIAMETERS ON THE ELECTRODE GAP DISTANCE



(a) 0.8 mm DIAMETER, 4 cm GAP LENGTH, GLOW VOLTAGE 14 KV.



(b) 1.25 mm DIAMETER, 4 cm GAP DISTANCE, GLOW VOLTAGE 20 KV.

FIG.(2) THE CURRENT TRACES REPRESENT APPEARANCE OF GLOW POSITIVE CORONA ON THIN WIRE AND STREAMER FORMATION ON THICKER WIRE AS RECORDED BY OSCILLOSCOPE FOR GAP DISTANCE 4 cm.

(2) INFLUENCE OF RESISTANCE:

The resistance of high value is connected in series with the gap to investigate the effect of such resistance on the different modes of corona. The effect of circuit resistance is clearly shown in fig(3). It clearly seen that the glow onset corona voltage depends on both conductor diameter and gap distance. As an comparison fig (4) is plotted to show the effect of circuit resistance on the glow onset voltage for different diameters without and with circuit resistance of 5 M ohm. It indicates that the circuit resistance increases the visual corona voltage and the rate of increase decreases by the increasing of wire diameter. The effect of circuit resistance on the corona voltage is not only investigated by measuring but also visually and by means of oscilloscope current traces. Figure demonstrates this effect very clearly for a copper conductor of 0.8 mm diameter at 4 cm gap from the earthed plate. It is very clearly seen in Figure (5a) that the three modes of corona occur on thin wire namely the glow or positive, negative corona and streamers at 11.5 K.V. and 5 M-ohm circuit resistance. As the circuit resistance is increased to 10 M-ohm the two undesirable modes of corona are disappeared even at higher voltage of 15 K.V. (Figure (5b) Further increase in the circuit resistance reduces the glow of corona along the thin wire Figure (5c) which is recorded for 15 M-ohm circuit resistance at 18 K.V. Thus, the circuit resistance has a desirable effect on both boltage and modes of corona on thin wires.

(3) INFLUENCE OF CONDUCTOR MATERIAL:

In the present work, aluminium, copper and steel wires are used as an example to investigate their effect on the glow corona voltage. The glow corona voltage for different conductor materials is shown in fig (6) , where

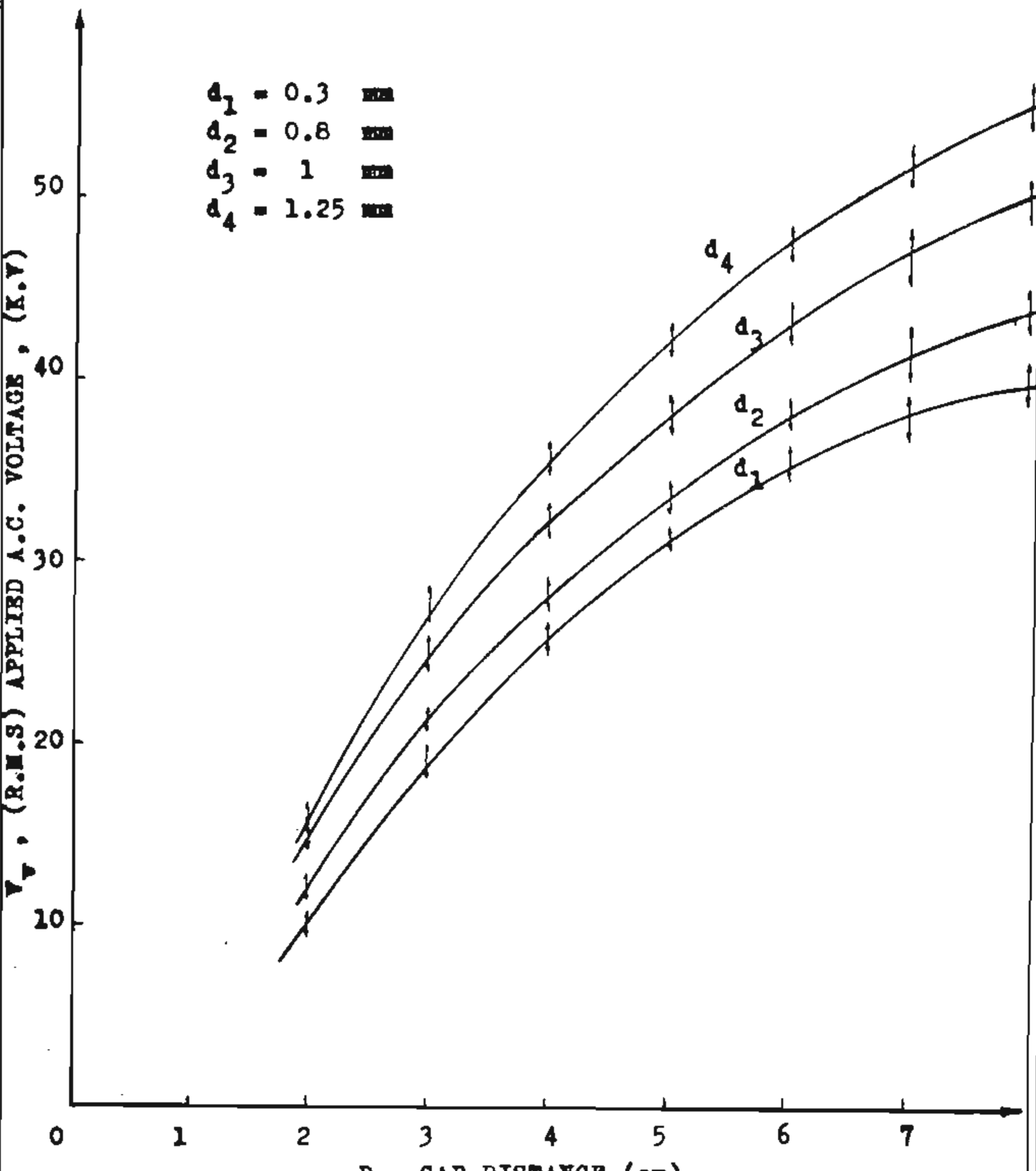


FIG.(3) THE DEPENDENCE OF GLOW ONSET VOLTAGE FOR DIFFERENT CONDUCTOR DIAMETERS ON THE GAP LENGTH IN THE CASE OF USING 5 M OHM RESISTANCE IN THE H.V. CIRCUIT

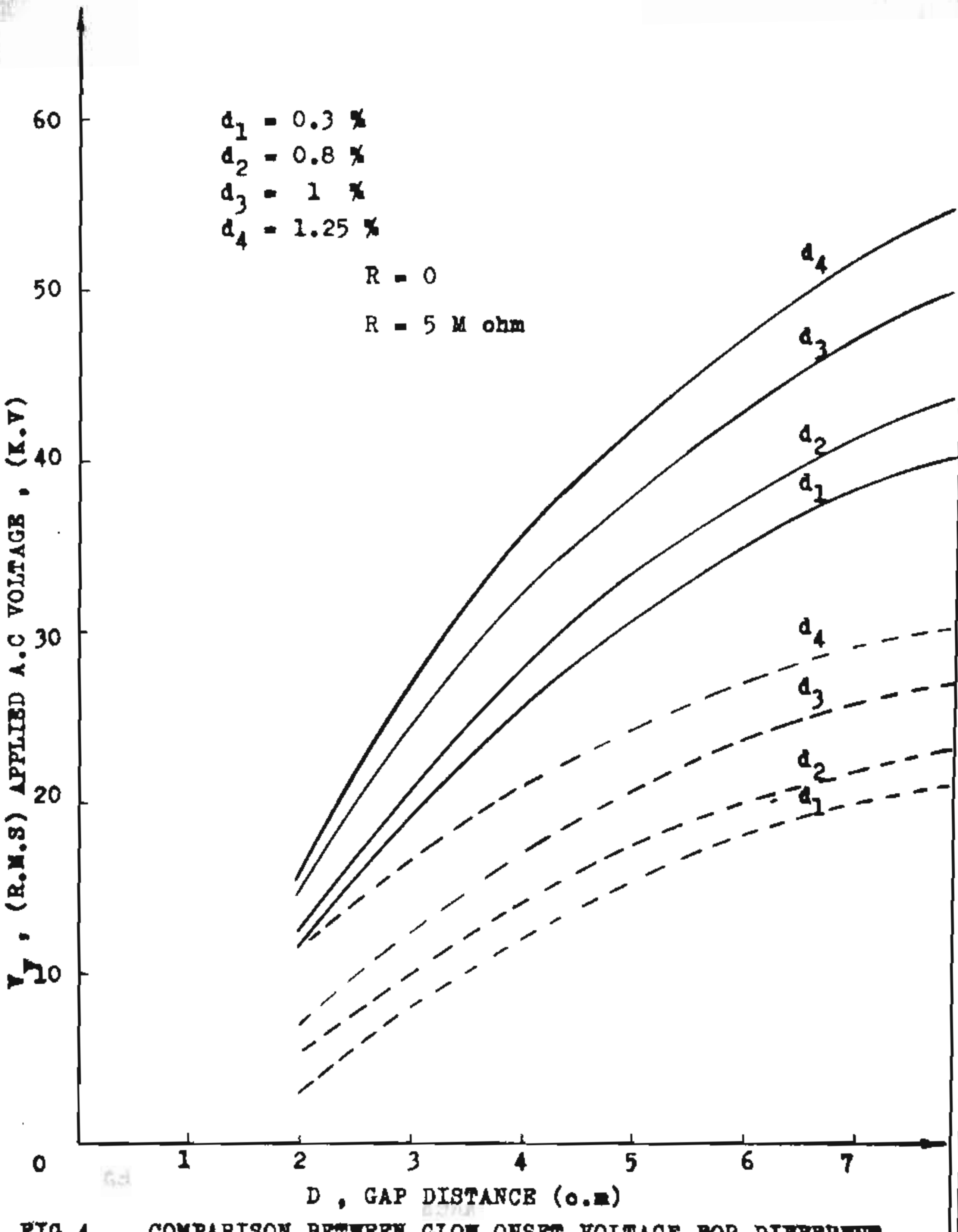
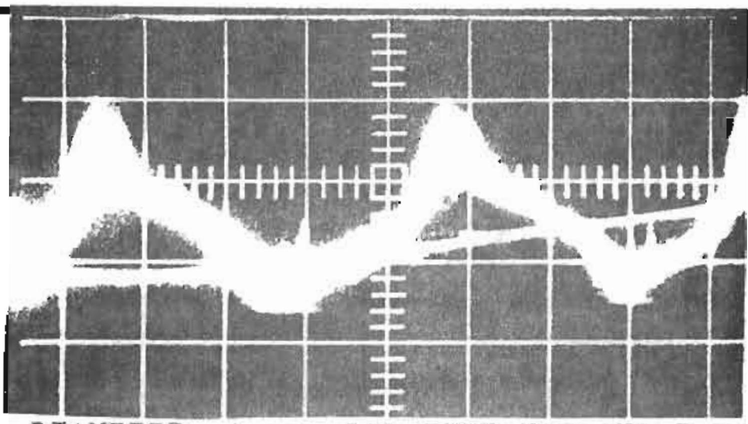
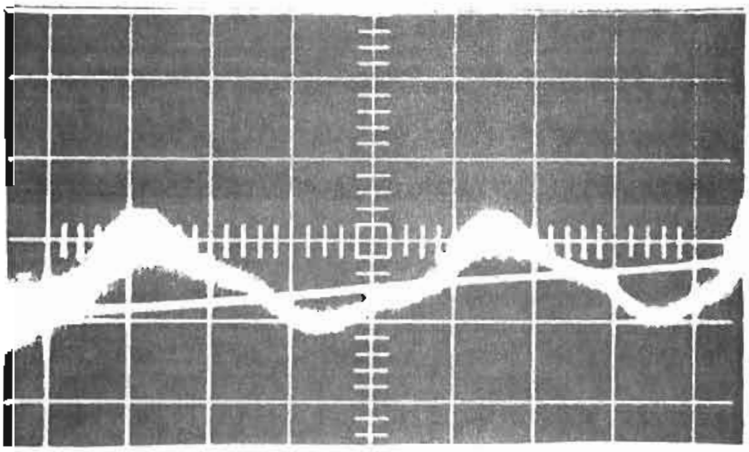


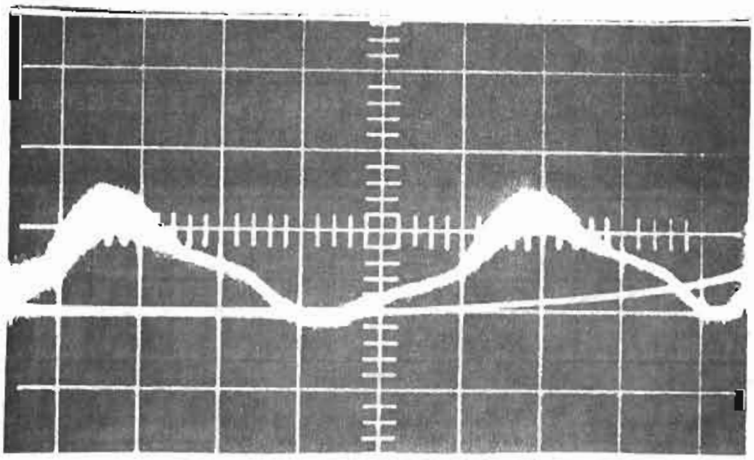
FIG.4 COMPARISON BETWEEN GLOW ONSET VOLTAGE FOR DIFFERENT CONDUCTOR DIAMETERS WITHOUT CIRCUIT RESISTANCE AND THAT WITH CIRCUIT RESISTANCE OF 5 M OHM IN THE H.V GENERATING CIRCUIT



(a) 0.8 mm DIAMETER, 4 cm. GAP DISTANCE AND 5 M OHM, THE GLOW CORONA VOLTAGE IS 11.[illegible] KV.



(b) 0.8 mm DIAMETER, 4 cm. GAP DISTANCE AND 10 M OHM, THE GLOW CORONA VOLTAGE IS 15 KV.



(c) 0.8 mm DIAMETER, 4 cm GAP DISTANCE AND 15 M OHM, THE GLOW CORONA VOLTAGE IS 18 KV.

FIG.(5) THE EFFECT OF CIRCUIT RESISTANCE ON THE GLOW CORONA VOLTAGE AS RECORDED BY OSCILLOSCOPE TRACES

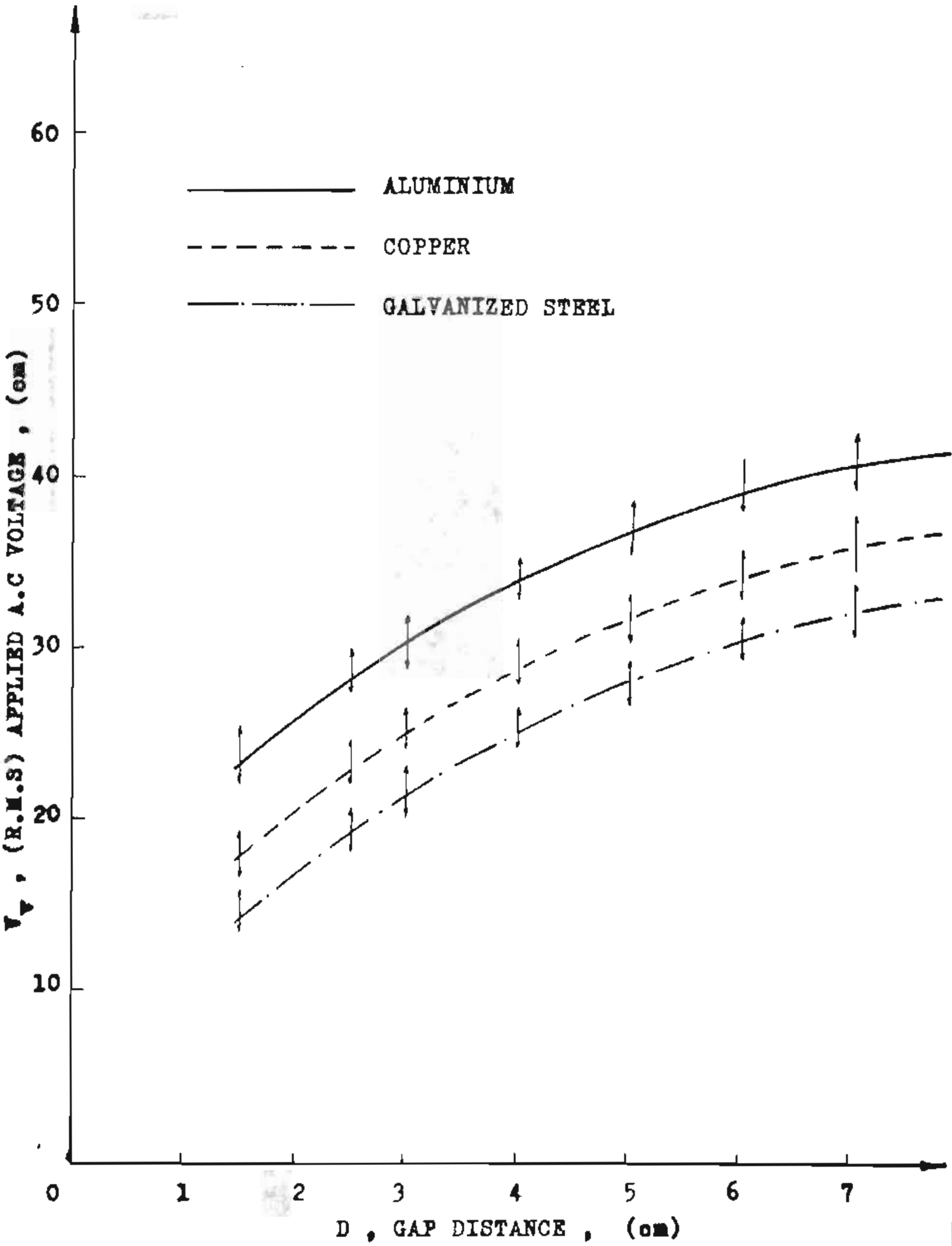


FIG.(6) THE VARIATION OF THE GLOW ONSET CORONA VOLTAGE WITH THE GAP DISTANCES FOR DIFFERENT WIRE MATERIALS EACH OF 2 mm CONDUCTOR DIAMETER the wire diameter is 2 mm. It is cleary seen that for the same gap distance the steel conductor gives the lowest glow corona voltage values while the aluminium conductor has the highest glow corona voltage values.

(4) INFLUENCE OF HUMIDITY AND POLLUTION.

Atmospheric conditions such as the temperature and pressure of surrounding air also have a pronounced effect on the critical corona voltage. This is because of the mean freepath of the electron is inversely proportional to the temperature. The breakdown voltage of a gas is directly proportional to its density . The breakdown voltage of an air gap is affected by the atmospheric conditions and correction factor must be taken into account to convert the breakdown voltage to the standard atmospheric conditions namely 760 mm hg pressure and 20 c° temperature. In the present work this effect is investigated considering both the humidity and pollution of the atmospheric air. The relative humidity is obtained by means of manually operated sprayer having 500 c.cm capacity . The relative humidity is measured by means of a hyprometer. The value of the relative humidity is recorded after intervals of 3 minutes until the pointer of the hygrometer takes a fixed position. The pollution is obtained by spraying a solution of 100 gm gypsum in 500 c.cm distilled water. The dependence of visual corona voltage on the relative humidity for different conductor diameter is shown in Fig (7) at 4 cm gap distance. It is clearly seen that this voltage depends strongly on the relative humidity. The visual corona voltage decreases by increasing of the relative humidity. As a comparisin, the glow corona voltage for a copper conductor of 2 mm diameter as a function of gap distance in dry air, under 50% relative humid-pollution conditions is clearly seen in Fig (8) .

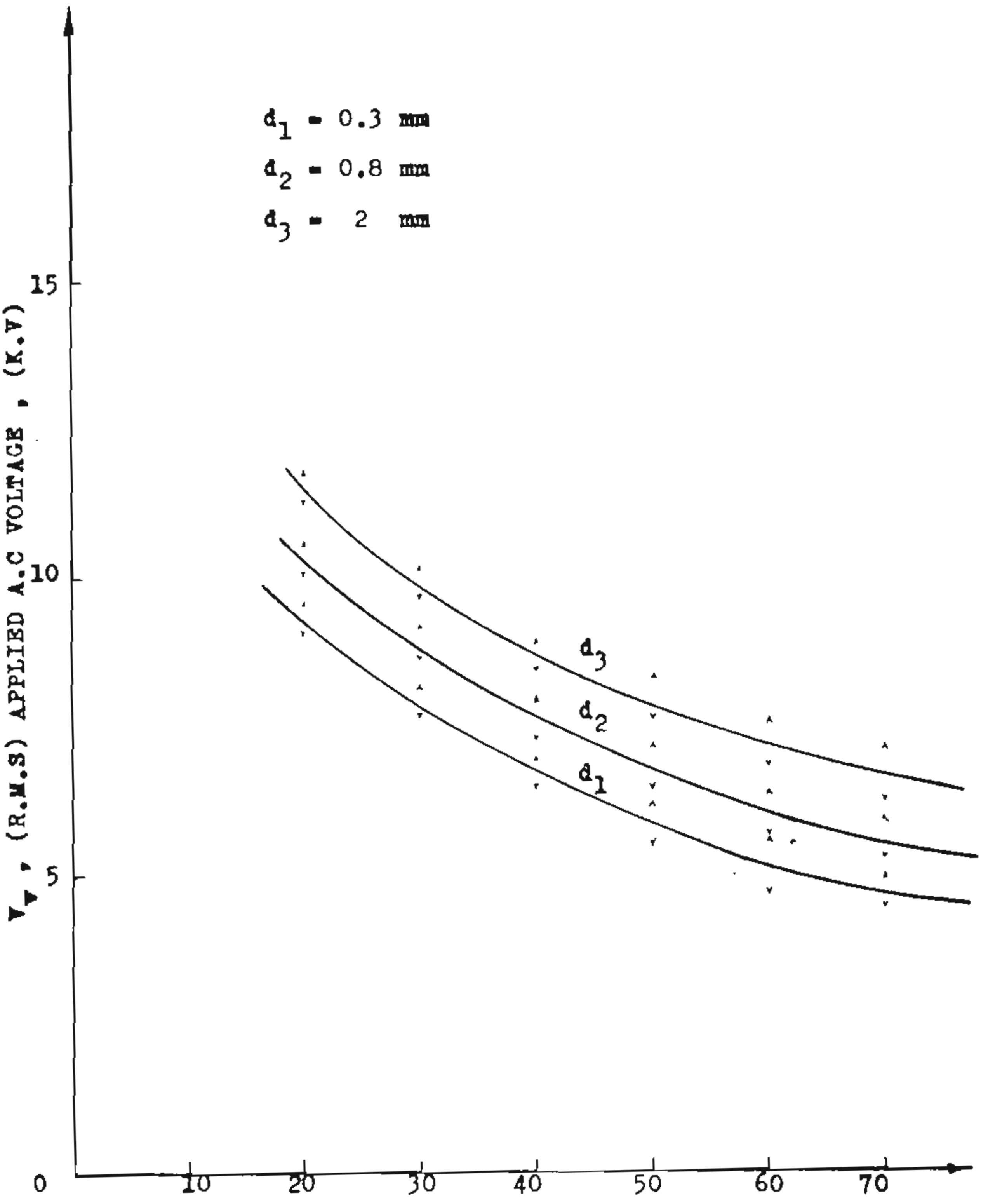


FIG.(7) THE DEPENDENCE OF GLOW ONSET VOLTAGE ON THE RELATIVE HUMIDITY FOR DIFFERENT CONDUCTOR DIAMETERS AND 4 cm GAP DISTANCE

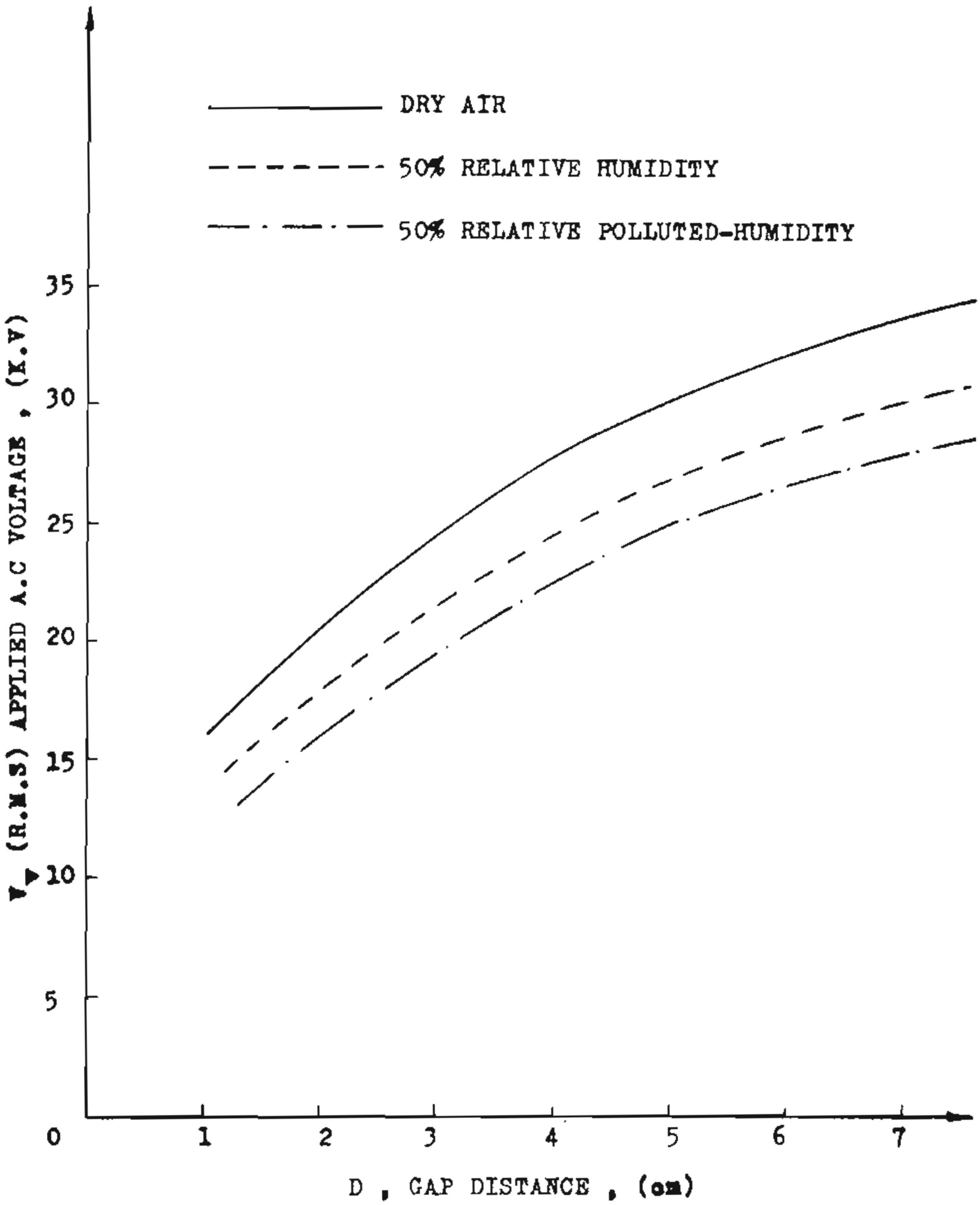
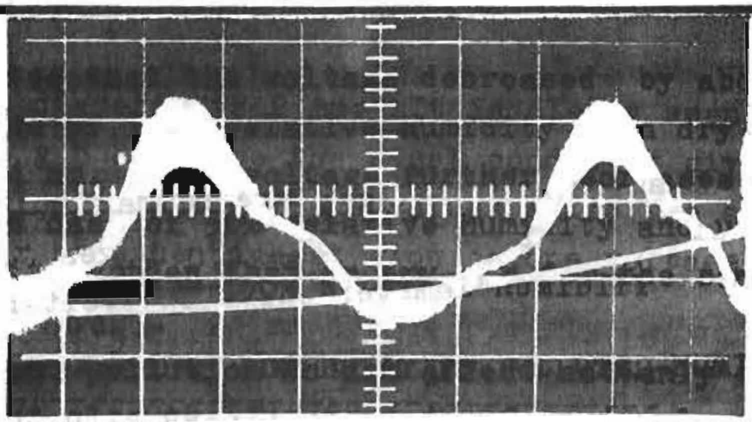


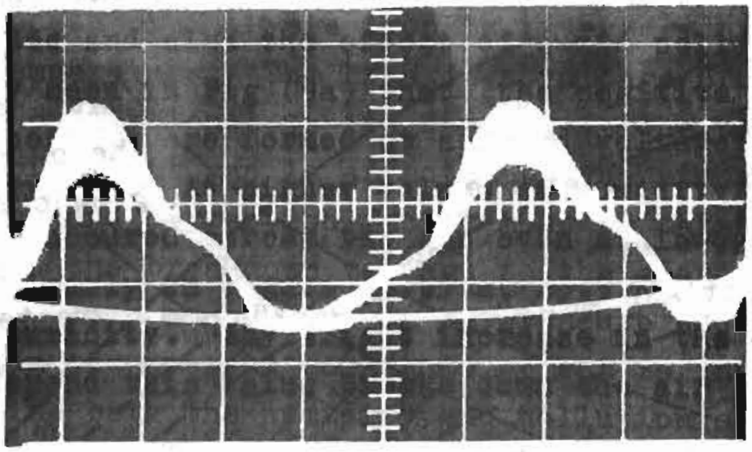
FIG.(8) THE EFFECT OF WEATHER CONDITIONS UPON THE GLOW ONSET CORONA VOLTAGE GAP LENGTH CHARACTERISTICS FOR 2 mm WIRE DIAMETER

It indicates that the voltage decreased by about 3 K.V in the case of 50 % relative humidity than dry air for gap distance 4 cm. This voltage further decreases about 10 K.V in the case of 50% relative humidity and under pollution condition than that in dry air for the same gap distance.
Humidity and pollution do not affect not only the corona voltage but also the corona modes formed along the thin wire. This is illustrated clearly in Fig (8) which is recorded for wire diameter 0.8 mm and gap distance 4 cm. Fig (4) shows the effect of the relative humidity on the corona modes and also the effect of humid pollution. It is clearly seen in Fig (9a) that the positive and negative coronas are formed at applied voltage of 28.5 K.V. in dry air. At higher values of humidity small sparks are occured across the gap even at lower voltage as shown clearly in Figure (9.b) at 23.5 K.V. and 50 % relative humidity. Any slight increase in the aoplied voltage beyond this value breaks down the air gao.

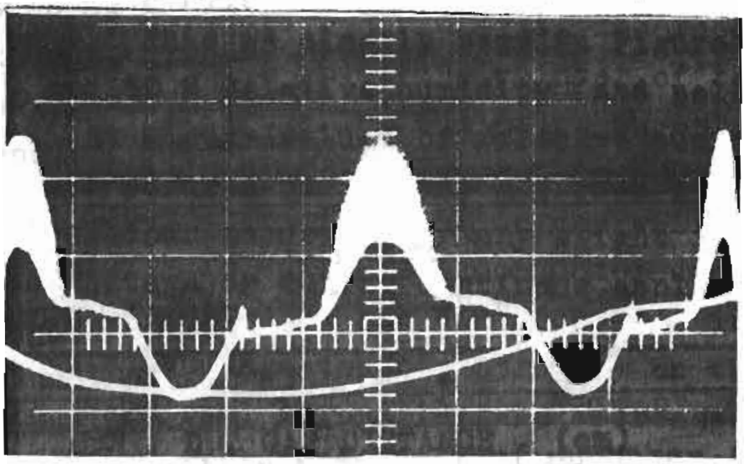
Humid pollution has a noticeable effect on both breakdown and corona in air gaps. Positive corona and streamers are formed at lower voltage than that under humidity only. This is clearly seen in Figure (9.c) at 19.5 K.V. and 50 % relative humidity and polluted conditions. At higher values of relative humidity, micro discharges are occured across the gap even at lower voltage. Breakdown occurs after any slight increase in the applied voltage or during continous application of this voltage.



(a) APPLIED VOLTAGE IS 28.5 KV. IN DRY AIR



(b) APPLIED VOLTAGE IS 23.5 KV. 50% RELATIVE HUMIDITY



(c) APPLIED VOLTAGE IS 19.5 KV., 50% RELATIVE HUMIDITY
UNDER POLLUTION CONDITIONS

FIG.(9) OSCILLOSCOPE TRACES SHOWING THE EFFECT OF BOTH HUMIDITY AND POLLUTION ON CORONA MODES IN AIR GAP OF 4 cm, FORMED ALONG A WIRE OF DIAMETER 2 mm.

CONCLUSIONS

The results of this work are summarized as follows:

(1) The different modes of corona voltages depends strongly on wire diameter where the voltages increase as wire diameter is increased.

(2) The resistance connected in series with the electrode rises the critical corona voltage for the same wire diameter and same gap distance and if the circuit resistance is increased the burst pulse voltage increases also.

(3) For positive corona it is observed that the circuit resistance affects burst pulse and the onset streamer which appear at the same time with glow corona.

(4) With the same resistance and gap distance the rate of increase due to the resistance is greater for smaller diameters rather than thicker wires.

(5) With added circuit resistance the breakdown voltage is linearly related to gap distances over a wide range of spacings.

(6) Investigation of conductor materials on corona phenomena indicates that for the same gap distance the steel conductor gives the lowest glow corona voltage while the aluminium conductor has the highest glow corona values.

(7) Deposits on the conductor surface such as moisture, dust produce a roughness effect which lowers the corona voltage.

(8) The critical and visual corona voltages are depending strongly upon pollution and humidity where these voltages decrease by increasing of relative humidity or relative moistened - pollution.

(9) For the same relative humidity the glow corona voltages are smaller under relative moistened-pollution conditions than those under humid conditions.

(10) for wires higher than 1.6 mm diameter there is a critical gap length (4 - 6 cm) in the breakdown voltage against gap length in which breakdown voltage decreases rapidly because of the appearance of positive streamers.

(11) Positive corona is always initiated by burst pulse while negative corona is initiated by regular pulses called trichel pulses.

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