MPS/Int. RF 64-20

20.11.1964

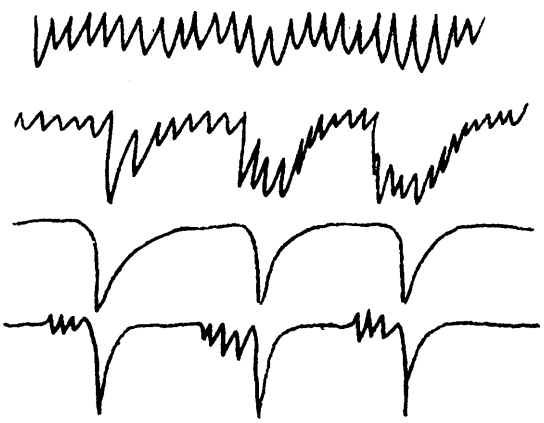
SOME RESULTS OF CORONA PHENOMENA INVESTIGATIONS

Introduction

In this report the first results of an investigation of corona phenomena occuring inside the middle electrode of a swinging cascade spark gap is given. (The use of corona discharge in spark gaps was proposed by F. Schneider).

Definitions and parameters

The corona, as observed by means of a photo-multiplier (P.M.) looking directly at the electrodes, was defined as follows :

	Definition	Single-shot oscilloscope display
1.	Steady corona	
2.	Steady corona and streamers	
3.	Streamers	
4.	Bad corona and streamers	

Description

Sub 1 : The display was a noisy signal. This corona noise (C.N.) showed a frequency of some hundreds of megacycles.

Sub 2 : The display showed streamer breakdown but even in the structure of the streamer breakdown C.N. could be observed.

Sub 3 : The only luminosity seen by the P.M. in this case were streamers.

Sub 4 : After a streamer no C.N. could be observed. Shortly after the appearance of some C.N. a streamer breakdown occurred after which the P.M. saw nothing for some time.

The types of 1 and 2 were considered to be suitable for our purpose, the types of discharge as defined under 3 and 4 were rejected.

The following parameters were investigated in order to obtain a discharge of the types 1 and/or 2.

List of parameters :

a Power supply voltage
b Chain resistance
c Air pressure
d Air flow
e Air humidity
f Air temperature
g Electrode configuration
h Electrode distance
i Voltage polarity across electrodes.

Discussion of parameters

Sub a : Power supply voltage was varied within the range of interest to us.

Sub b : Chain resistance (R e x t in drawing no 1) is given with each of the reported test results.

Sub c : The air pressure was varied over the range of 1 - 8 at. absol. (0 - 7 at. relative).

Sub d : The air flow varied between 0 and 10 lit/min. It was found that this parameter in this range has no influence upon the phenomena.

Sub e : The humidity of the air, which is known to be of importance, was kept at $\varphi \approx$ 25-30% at an ambient temperature of $\sim 20^{\circ}C$. This is not very dry, but it can be achieved technically without great cost. We simply fed the air supply through a reactor with silica gel (see Note no 1).

Sub e (contd.) :

The humidity was measured with the aid of the wet and dry bulb method and thermometer readings were converted into relative humidity values with a psychometric table.

In a report from the Culham Laboratories (Ref. 1) mention is made of a preferred absolute humidity of 2 gr. of water per m^3 of air or less, which corresponds to a relative humidity of about 30% or less at 20°C (ambient temperature was not given in Ref. 1).

Sub f : The air had a temperature of around 20°C for all reported tests. On the other hand variation over the temperature range of 16°C - 24°C did not show variations in performance.

Sub g : Various electrode configurations have been tested.

It was found that the best results were obtained with a flat negative electrode and, of course, a fine pointed positive electrode. Various needles for the positive electrode have been tested.

The magnified outlines of the majority of the tested needles are shown in figs. 3 and 4.

Needles no 100 and 101 were chemically sharpened. Especially no 100 shows the danger of this procedure. Needle no 100 was not tested for corona as it is obvious that it would be rather impossible to make other needles of similar shape.

To start with needle no 101, better results were obtained while changing to the higher numbered needles.

Very little, if any, difference was found in the performance of needles nos. 106 and 107.

The best results were obtained with the needle configuration of 108 where a 30 μ tungsten wire sticks out from a no 17 hypodermic needle. The 30 μ tungsten wire is simply stretched by hand until it breaks.

A remark on the reproducibility of the commercially obtained needles. It is clear that it will be difficult to specify such a parameter from needles mechanically or chemically sharpened in our workshops.

Sub g (contd.):

Milwards needles (nos. 104 and 105) are as far as the point is concerned not quite reproducible (6 measured).

Wittekind needles (no. 103) are fairly well alike (6 measured). The hypodermic needles (nos. 106, 107, 108) of the same make and size are extremely well reproducible (of each type 5 tested - hardly any difference found).

The sewing needles were bought at Grand Passage.

The hypodermic needles :

Make : Delvo — NP Stores no. 17
Pharmacie Meyrin no. 20 (not shown)

Make : Platinum — Pharmacie Principal nos. 18, 20 and 22 (nos. 20 and 22 not shown).

Sub h : The electrode distance in all reported tests was 6 mm .

Sub i : The needle in all reported tests was the positive electrode. Investigation easily showed that the polarity should not be reversed if one looks for corona of type 1 .

Test results

In these test results the markings under the heading "Corona Conditions" bear the following meaning :

0 = Discharge of type 1
OX = Discharge of type 2
(these 2 conditions are suitable)
X = Discharge of type 3
+0 = Discharge of type 4

Test 1 :

Humidity: < 30%

Temperature: ~19°C

Needle: Pt. needle no. 102

Polarity: needle pos.

External resistance : 6000 Mohms each

Flow: 0 - 10 lit/min.

Pressure	Cor. Conditions	Voltage (= ½ volt as measured by the electrostatic voltmeter, see fig. 1)
0	0	15 - 55 kV
	0X	55 - 60 kV
1	0	15 - 50 kV
	0X	50 - 60 kV
2	0	15 - 20 kV
	0X	20 - 50 kV
3	0X	15 - 25 kV

All other pressures and voltages : Corona of the types 3 and 4 .

Test 2 :

Humidity: < 25 %

Temperature: ~ 21°C

Needle: Sewing needle no. 104 or 105

Needle polarity : pos.

External resistance : 1500 ohms each

Flow : 0 - 10 lit/min.

Pressure range	Corona conditions	Voltage range
0 - 7 at. rel.	0X	20/25 - 60 kV
0 - 7 at. rel.	X	10 - 20/25 kV

Boundary at 25 kV for 5,6 and 7 at. rel.

Test 3 :

Needle : Hypodermic 18 no. 107

External resistance : 3000 Mohms each side

Other parameters as under test 2 .

Pressure range (at. rel.)	Corona conditions	Voltage range
0	0X	20 - 60 kV
1	0X	20 - 60 kV
2	0X	25 - 60 kV
3	0X	25 - 60 kV
4	0X	25 - 60 kV
5	0X	25 - 60 kV
6	0X	30 - 60 kV
7	0X	30 - 60 kV

Test 4 :

Needle : No. 108

External resistance : 1500 Mohms each side

Other parameters as under test 2

Pressure range (at. rel.)	Corona conditions	Voltage range
0 - 8	mainly 0 some bands of 0X	15 - 60 kV

Test 5 :

External resistance : 3000 Mohms each side

All other parameters as under test 4

Pressure range	Corona conditions	Voltage range
0 - 8	0	20 - 60 kV

Test 6 :

External resistance : 4500 Mohms each side.
All other parameters as under test 4.

Over the same pressure range the conditions for test 5 could not be met. Discharges of types 3 and 4 occurred in this test.

Test 7 :

While discussing the design of the spark gaps for the ejection system it became clear that a single corona needle would not fulfil the requirements. Therefore the following test has been carried out :

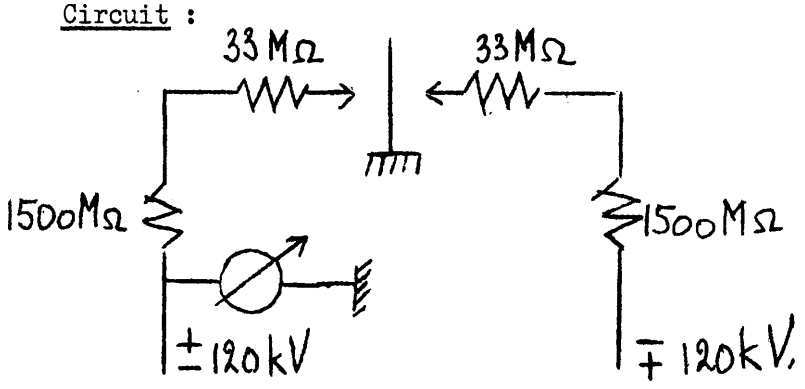
Two corona-needles (both of the type 108) produce a respectively positive and negative corona versus a plane. The positive corona (i.e. the needle is positive), as was found out before, is much steadier than the negative corona at the same corona current.

However, the circuit is entirely symmetrical and thus, when the polarity across the gaps is reversed, one needle always produces a corona of type 1 or 2.

Test results : (Both needles 108, distance to plane ca.6 mm).

Pressure range	Corona conditions	Voltage range
0-8 (at. rel.)	mainly OOX some bands of OX	20 - 60 kV

Circuit :



Conclusions

The corona discharges of the types we were looking for occurred under the conditions of tests 4, 5 and 7.

These measurements were repeated and gave the same results.

At this stage of the work life tests have to be carried out still.

K. Gase

Acknowledgment

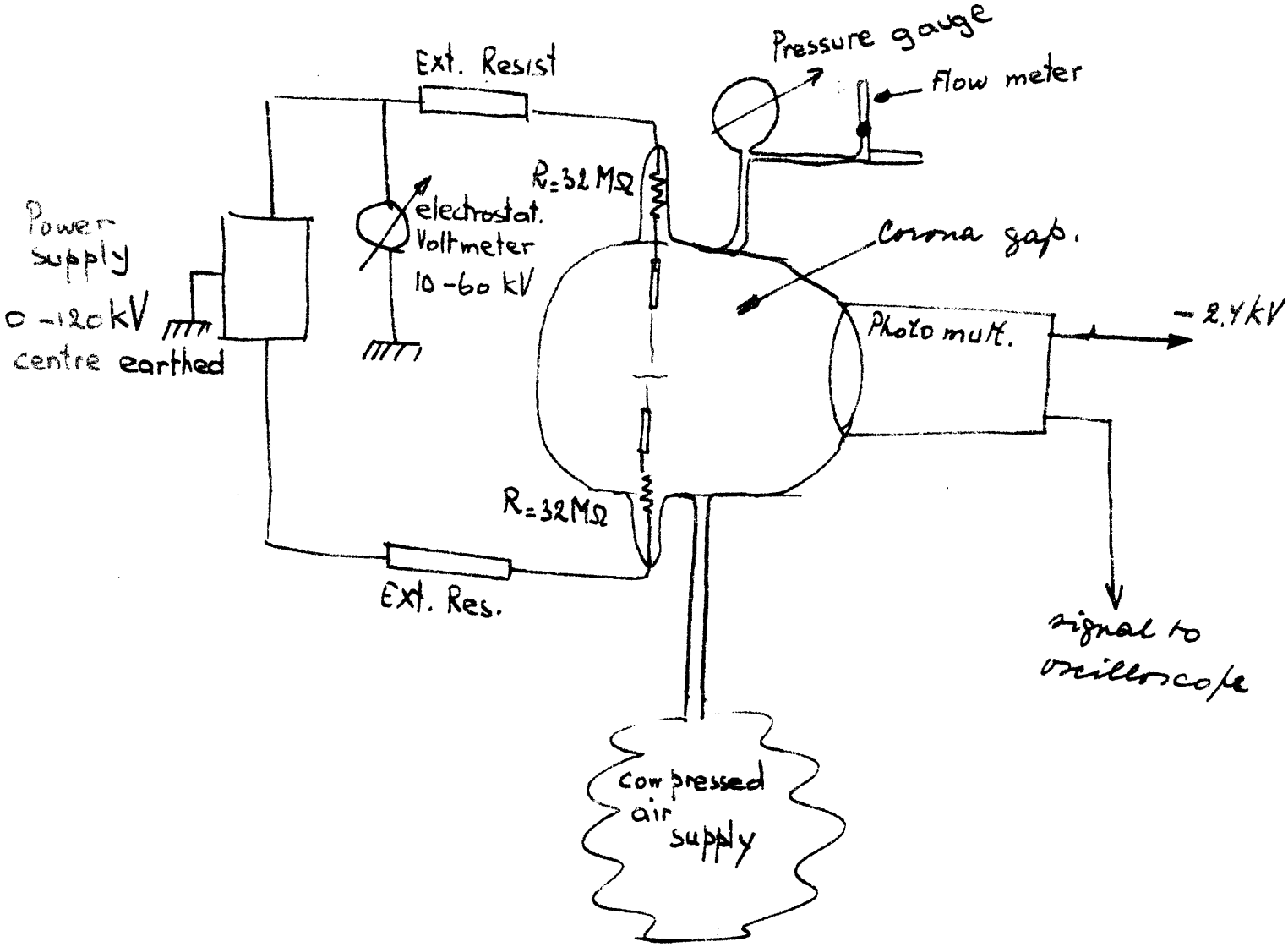
I wish to express my gratitude to Mr. R. Godet who lent me the microscope.

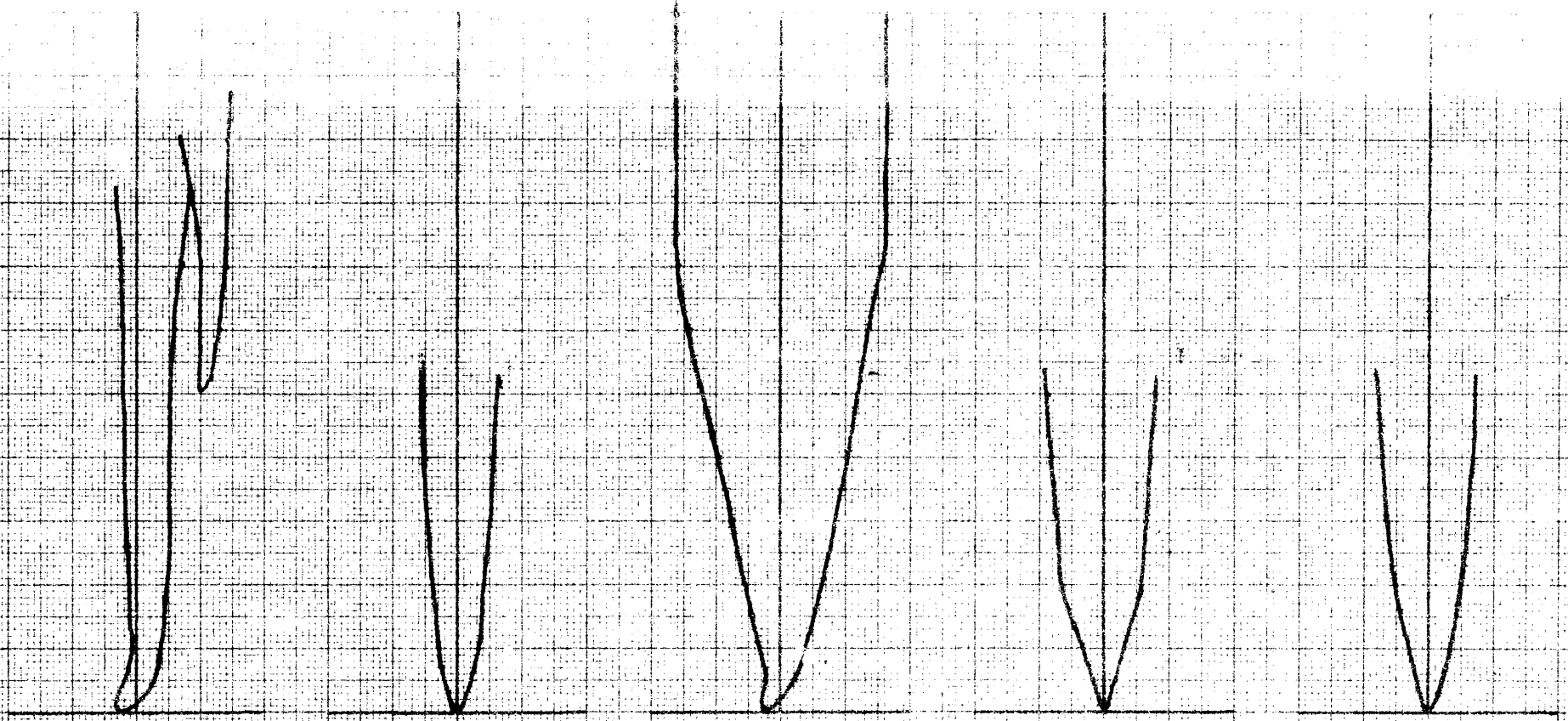
Distribution : (open)

MPS Scientific Staff

G. Primadei
H. Simpson
R. Godet, SB
F. Krienen, NP
F. Schneider, AR

fig 1


Ext. Resist
Pressure gauge
Flow meter
R=32 MΩ
electrostat.
Voltmeter
10-60 kV
Power
supply
0-120 kV
centre earthed
Corona gap.
Photo mult.
-2.4 kV
R=32 MΩ
Ext. Res.
signal to
oscilloscope
compressed
air
supply



WOLFRAM NEEDLE
№ 1
CHEM. SHARPENED
100

WOLFRAM NEEDLE
№ 2
CHEM. SHARPENED
101

PLATINUM NEEDLE
№ 1
Mech. Sharpened
102

MILWARDS Sewing
Sharps 5/10
Small
№ 1
Stainless steel
104

Wittekind Sewing
№ 1
Smallest.
Stainless steel
103

Fig nº 2 Corona Needles
Scale : 1cm = 0.14mm

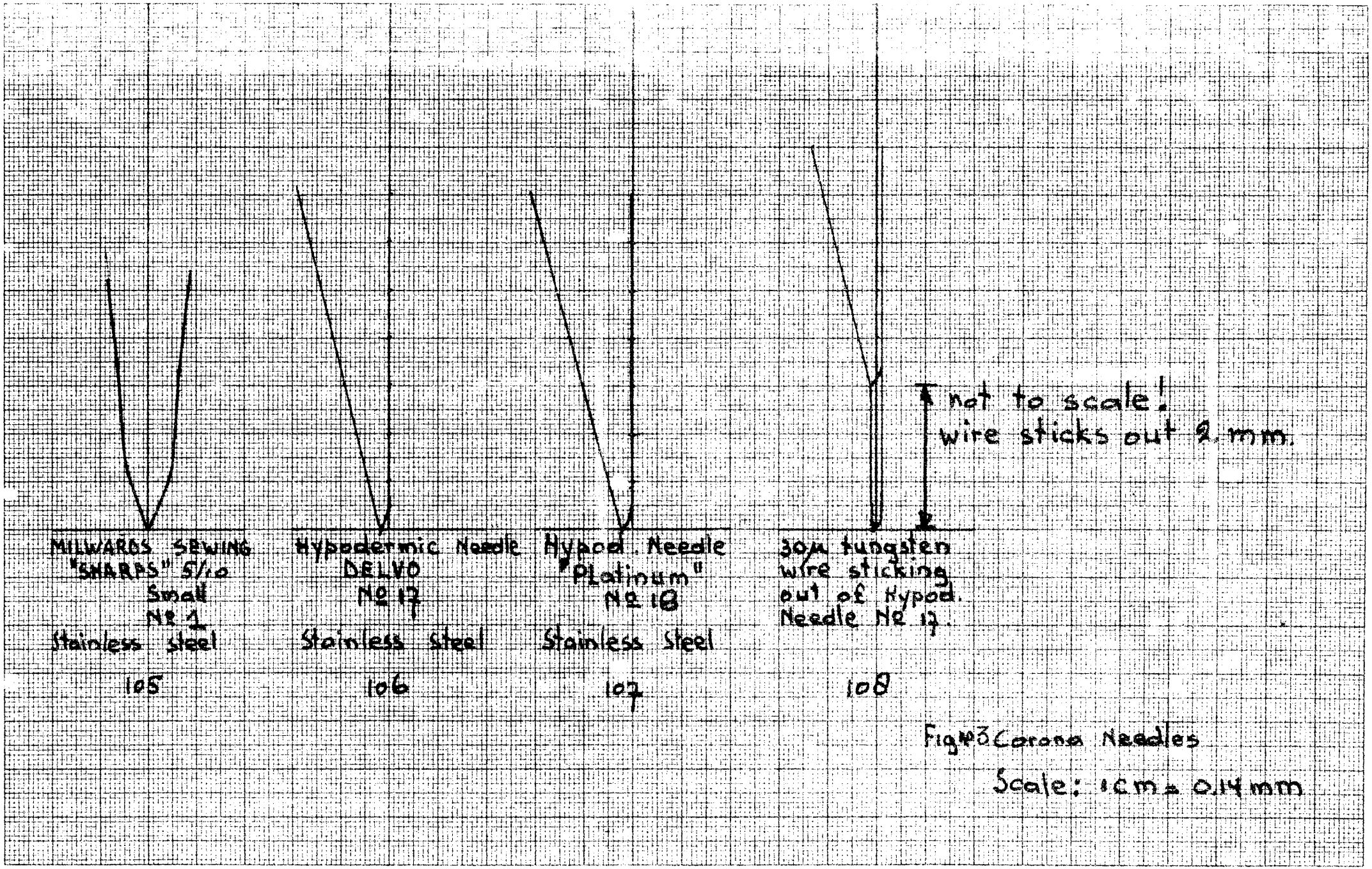


Fig 3 Corona Needles

Scale: 1 cm = 0.14 mm