LIGO-T960225-00-D

Object: Outgassing measurements of alumina insulated cables

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In this note we briefly report the results obtained on alumina insulated cables selected for a possible use for Virgo coils. The test apparatus is described in detail in the note VACPISA 025. The outgassing is measured using the dynamic method: measuring both pressures in the sample chamber P_1 and in the pumping chamber P_2 the total outgassing flow can be deduced from the relation:

$$Q = (P_1 - P_2) \times C \tag{1}$$

where C is the conductance (20 l/s N_2 equivalent at 20^0C). The measurement is performed twice, with and without the sample into the sample chamber: the difference between the two flow values will represent the net sample outgassing; the difference in the RGA spectra will give the mass distribution of the sample outgassing.

1 - System performances

After baking the base pressure of the chamber is of the order of 10^{-9} mbar and the outgassing rate of the order of 10^{-11} mbar l s^{-1} cm^{-2}. The main components of outgassing are H_2, H_20, N_2/CO, CO_2.

2 - Measurement of the outgassing flow of alumina insulated cables

We have tested 50 m of alumina insulation cabling (0.5 mm diameter conductor with 10 µm alumina thickness) produced by Dipsol Chemicals, Japan. The surface exposed to vacuum was 785 cm^2. The total resistance of cables was 16 Ω. The temperature rise of the cables was measured both by a thermocouple in contact with the cables and by the measurement of conductor resistance (measurement of both voltage and current).

The decrease of pressure in the chamber with samples was very fast:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
0.5	19	$1.3\text{x}10^{-5}$	$1.6\text{x}10^{-6}$	$2.3\text{x}10^{-4}$
1	19	$7.0\text{x}10^{-6}$	$7.4\text{x}10^{-7}$	$1.2\text{x}10^{-4}$
1.5	19	$3.7\text{x}10^{-6}$	$3.4\text{x}10^{-7}$	$6.7\text{x}10^{-5}$
3.5	19	$1.4\text{x}10^{-6}$	$1.3\text{x}10^{-7}$	$2.5\text{x}10^{-5}$
5.5	19	$8.7\text{x}10^{-7}$	$8.0\text{x}10^{-8}$	$1.6\text{x}10^{-5}$
6.5	19	$7.3\text{x}10^{-7}$	$6.7\text{x}10^{-8}$	$1.3\text{x}10^{-5}$
28.5	19	$1.5\text{x}10^{-7}$	$1.4\text{x}10^{-8}$	$2.7\text{x}10^{-6}$
72	19	$6.8\text{x}10^{-8}$	$8.1\text{x}10^{-9}$	$1.2\text{x}10^{-6}$
94.5	19	$2.8\text{x}10^{-8}$	$5.2\text{x}10^{-9}$	$4.6\text{x}10^{-7}$

The outgassing spectrum after 72 h is reported in Fig. 1. It is evident that there is no contamination from hydrocarbons.

We performed the baking of the system at 150^{0}C for 2 days:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
during	150	$3.3\text{x}10^{-7}$	$1.1\text{x}10^{-7}$	$4.4\text{x}10^{-6}$
after	19	$2.3\text{x}10^{-9}$	$4.7\text{x}10^{-10}$	$3.7\text{x}10^{-8}$

The spectrum taken during the baking is reported in Fig. 2. The spectrum after baking is reported in Fig. 3. The outgassing evolution is summarized in Fig. 4.

We tested the cables in operation with different currents:
- 10 mA for 7h: there was no sizeable temperature rise and final outgassing flow was $3.5\text{x}10^{-8}$ mbar l/s (Fig. 5) ;
- 100 mA for 16h: there was no sizeable temperature rise and final outgassing flow was $3.2\text{x}10^{-8}$ mbar l/s (Fig. 6);
- 1 A for 5h: in a few minutes the temperature increased to almost 200 ^{0}C and the pressure to $2.6\text{x}10^{-5}$ mbar; the final pressure and outgassing flow were $8.7\text{x}10^{-7}$ mbar and $7.6\text{x}10^{-6}$ mbar l/s (Fig. 7).

In no case we observed any contamination from hydrocarbons.

3 - Discussion

No contamination from hydrocarbon was observed neither during baking nor when current (up to a dissipation of several W) was flowing in the cable.

We summarize here the outgassing rates measured in different conditions:

- before baking, 72h pumping, no current: 5.8×10^{-10} mbar l s^{-1} cm^{-2}
- during baking, no current flowing : 5.6×10^{-9} mbar l s^{-1} cm^{-2}
- after baking, no current flowing : 4.7×10^{-11} mbar l s^{-1} cm^{-2}
- after baking, 0.2 W dissipation : 4.1×10^{-11} mbar l s^{-1} cm^{-2}

We conclude that cables with alumina insulation can be recommended for use in VIRGO. One km of 1 mm diameter cabling with 0.1 W dissipation will provide an outgassing flux of 1.3×10^{-6} mbar l s^{-1}. We will exploit the possibility of having coaxial cables with inorganic insulation and with the suitable flexibility for the signal transmission. Our results are in rough agreement with the factory specifications shown in Fig. 8.
We have observed that the alumina insulation cables do exhibit a low water vapour retention as compared to Kapton ones (see note VACPISA 036). The pumping time scales to achieve 10^{-7} mbar are of the order of hours for the former and of days for the latter. The outgassing rate in the same operating conditions are better by almost an order of magnitude for alumina insulated cables as compared to Kapton insulated cables.

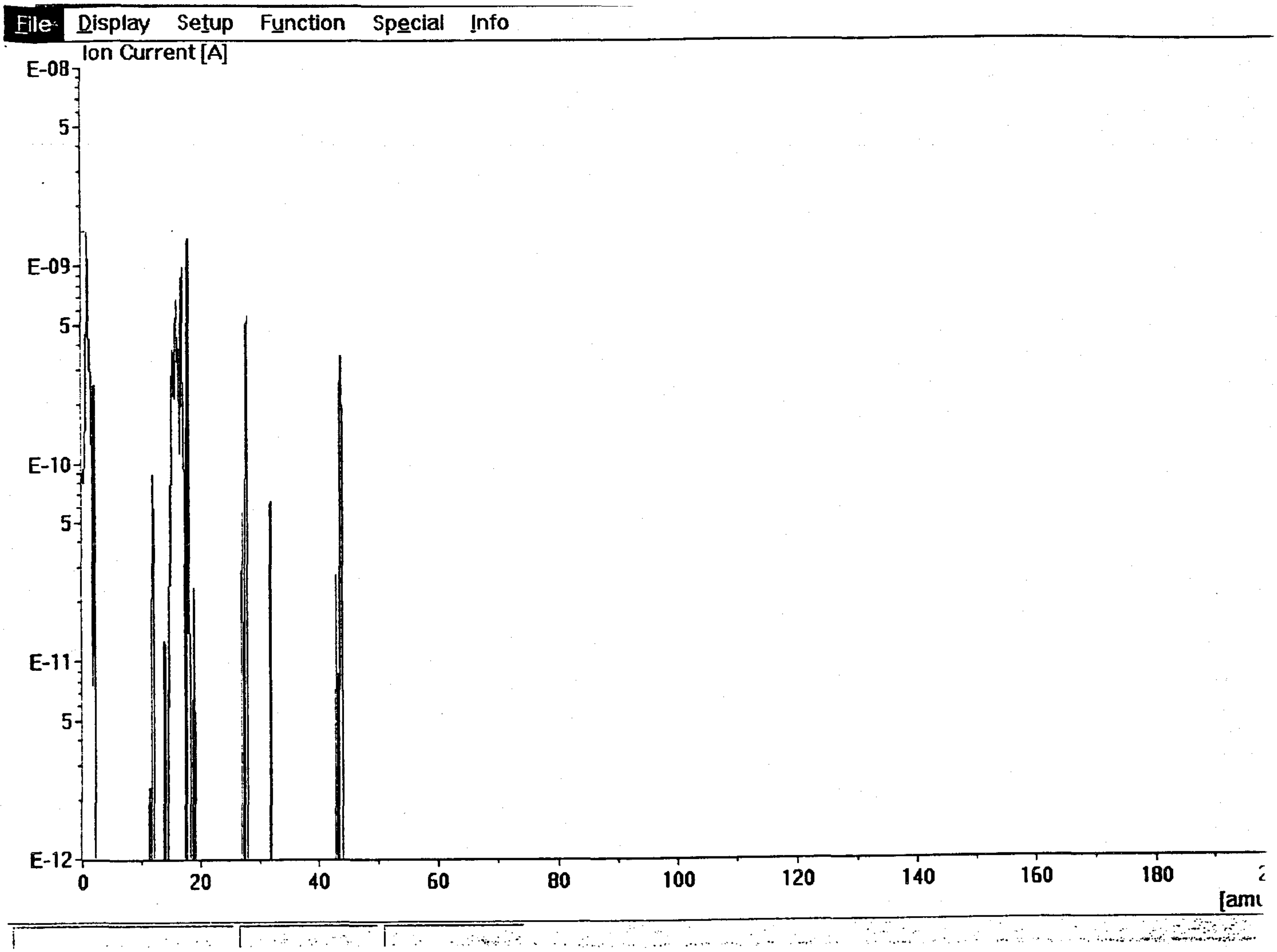
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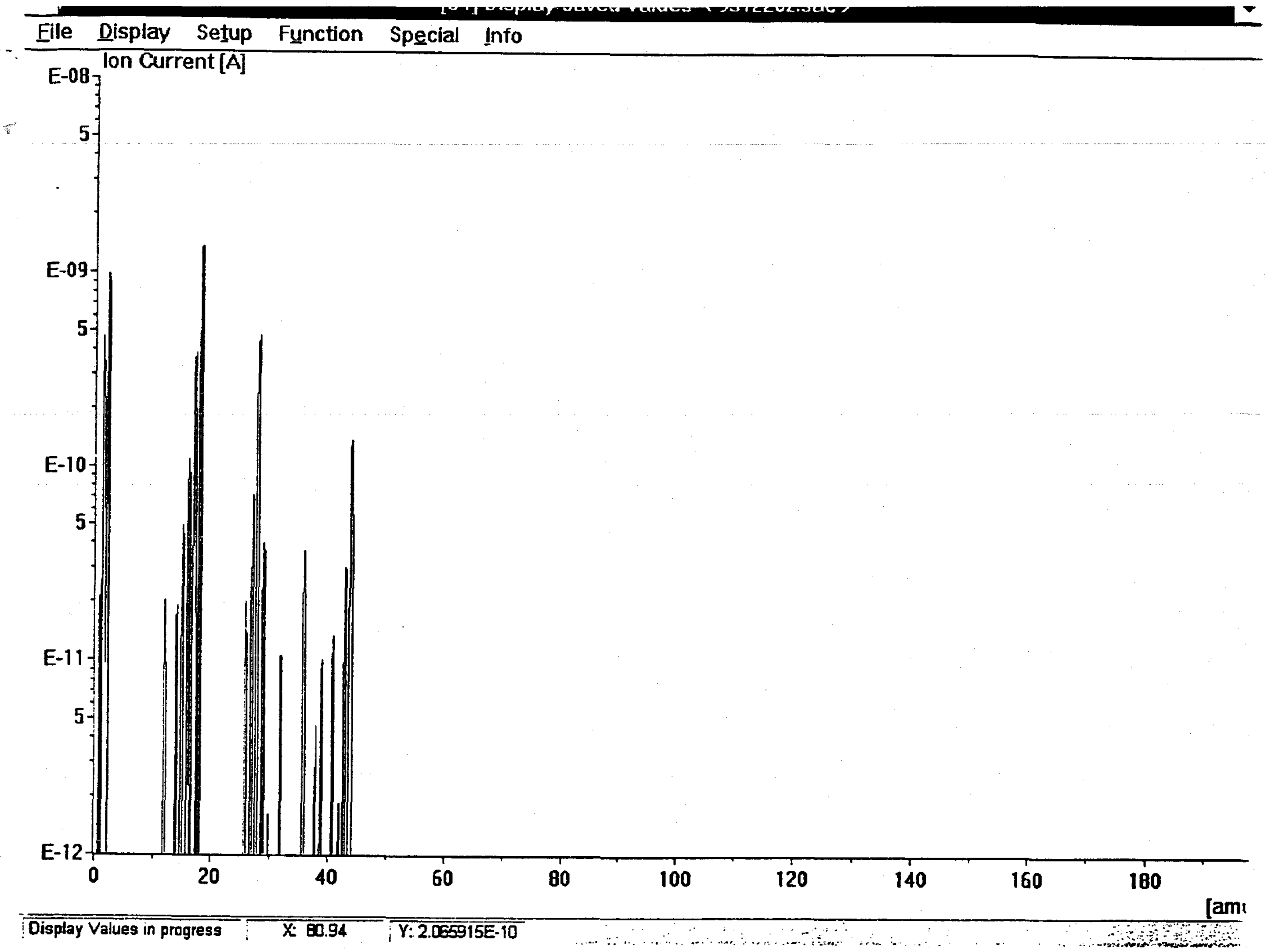
Fig. 1



Display Values in progress

X: 80.94

Y: 2.065915E-10

Fig. 2

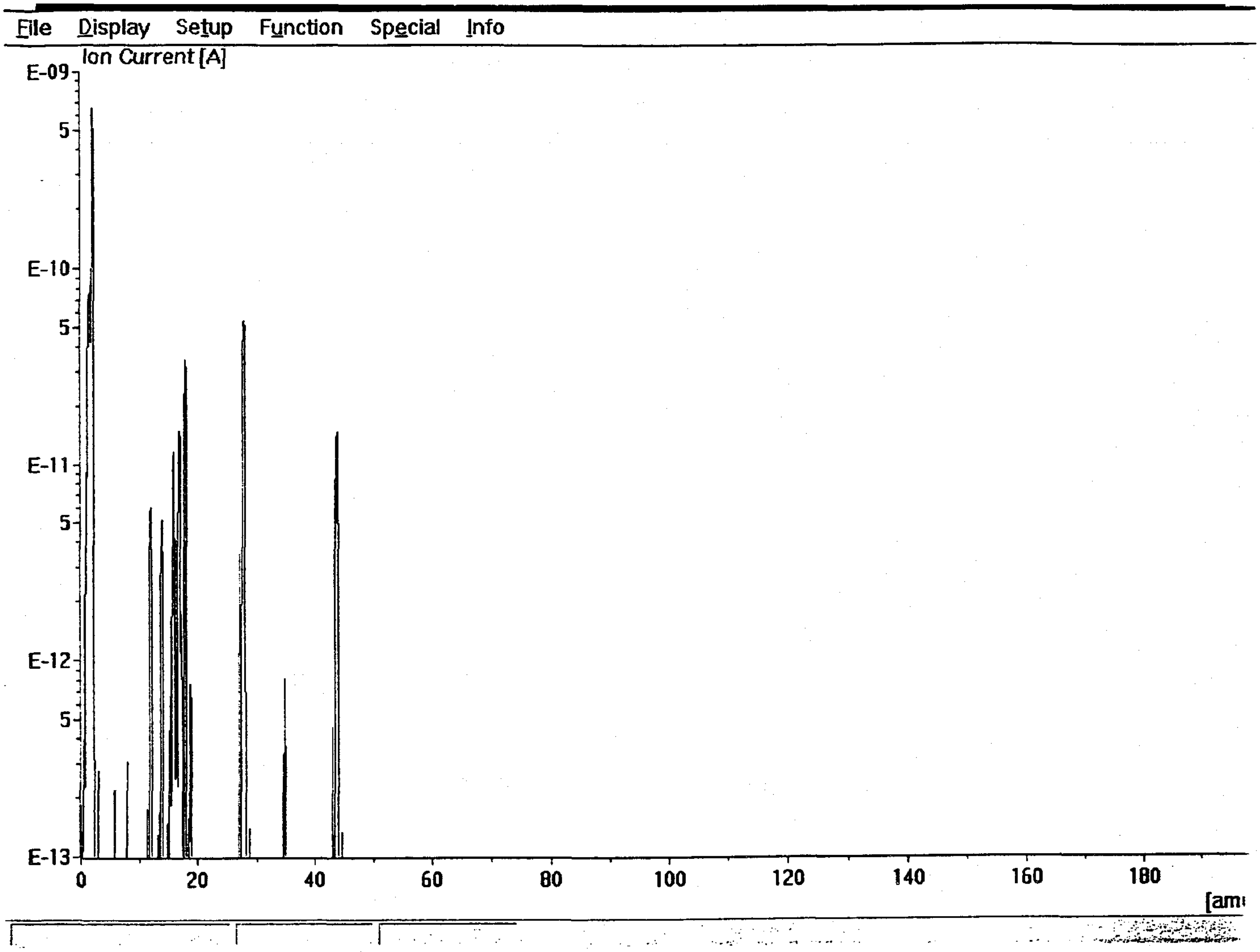

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Fig. 3

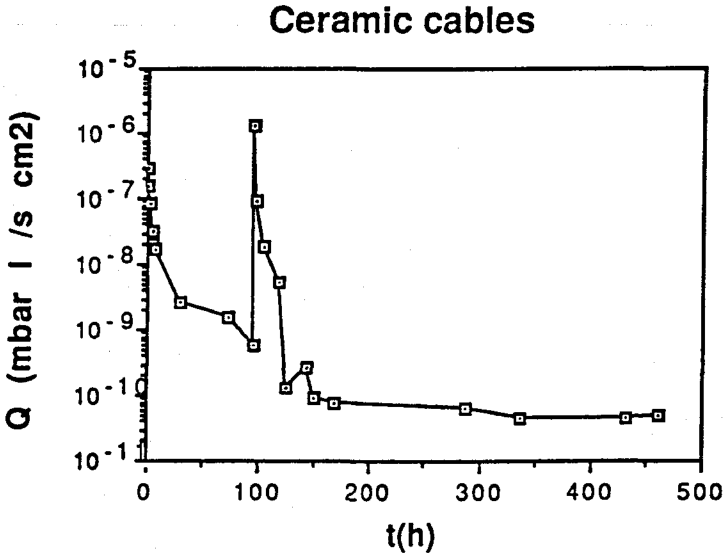
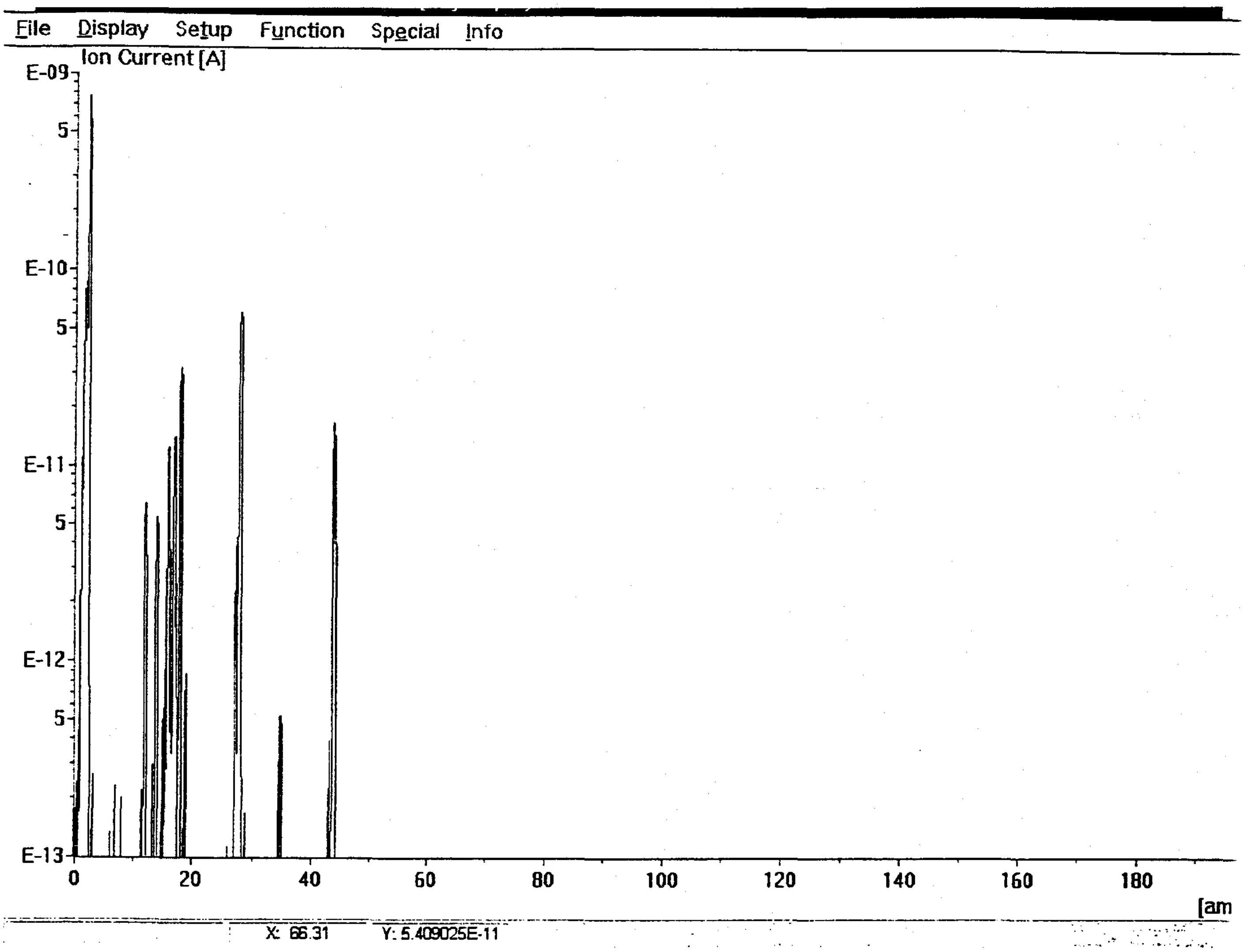

Ceramic cables
Q (mbar l /s cm2)
10^-5
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
0
100
200
300
400
500
t(h)

Fig. 4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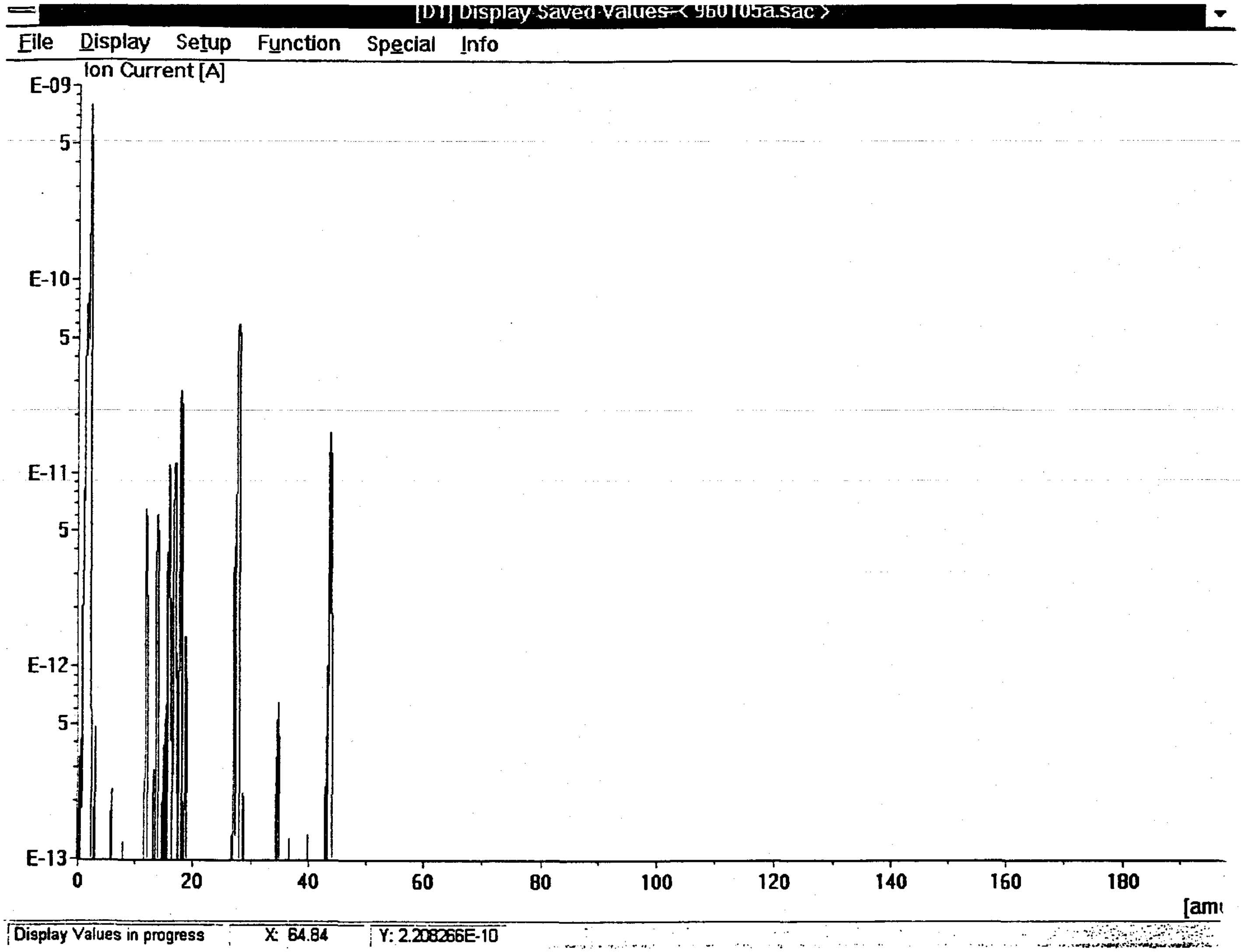
X: 66.31
Y: 5.409025E-11

Fig. 5

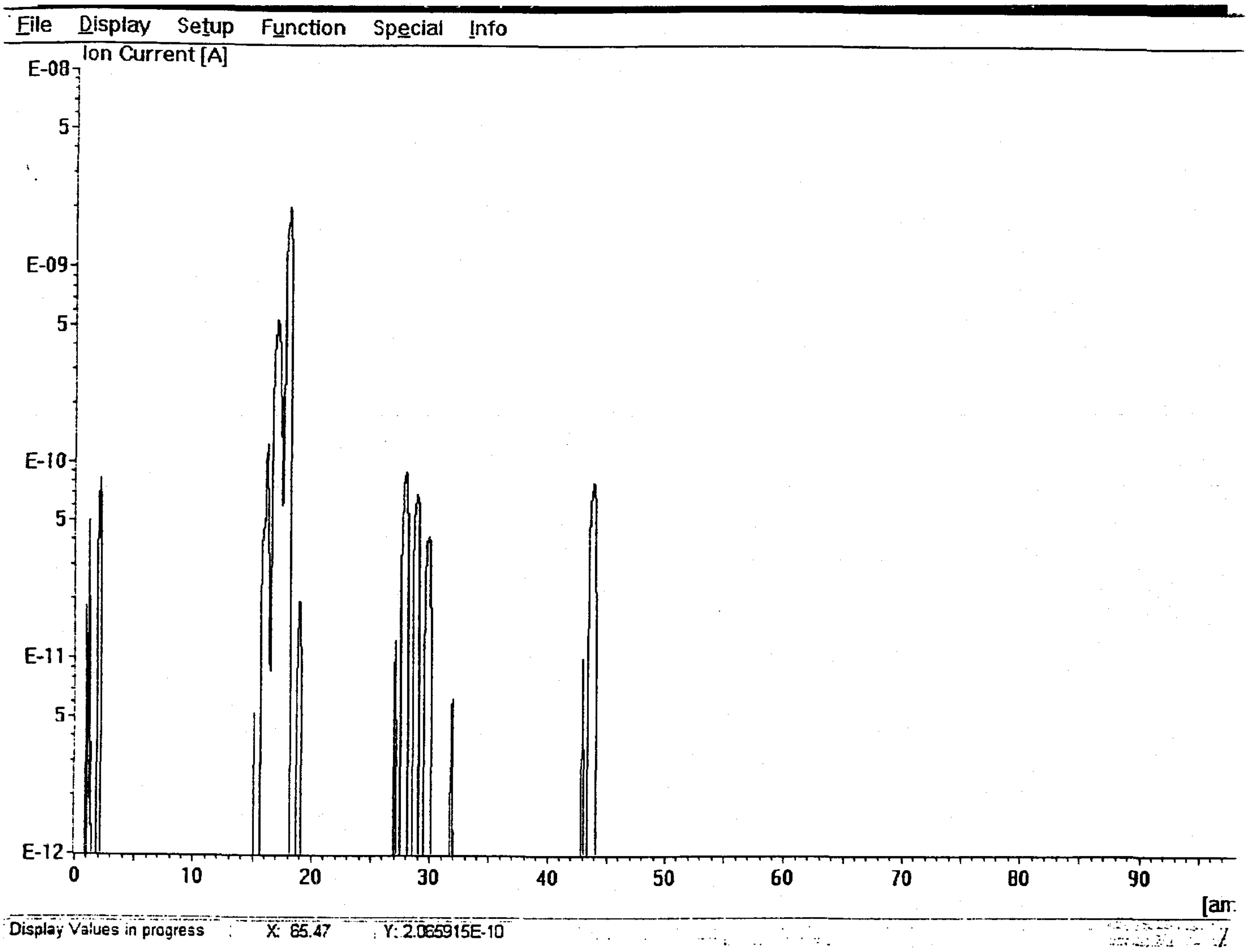


Display Values in progress

X: 64.84

Y: 2.208266E-10

Fig. 6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Display Values in progress
X: 65.47
Y: 2.065915E-10

Fig. 7

セラメッキ

（無機被覆電線シリーズ）

CERAMICS - COATED WIRE

セラメッキ電線

セラメッキ電線（セラミックス被覆電線）は、ディップソールのセラメッキ技術により電線の表面に絶縁体としてセラミックスを電解析出させた新商品です。

■ 特長

- ● 優れた電気絶縁性があります。
- ● 可とう性があるので、小口径のコイリング性にすぐれています。
- ● 絶縁皮膜が薄いので、スペースファクターが良好となります。
- ● 低温から高温までの熱変化によく耐えます。
- ● ガス放出が少ないため、超高真空中で使用できます。
- ● ガリウム、ハロゲンなどの腐食性雰囲気によく耐えます。

■ 用途

真空、放射線雰囲気、腐食性ガス、耐熱性の要求される環境下での信号線、マグネットコイルなど。

■ 特性

表1．皮膜種類と絶縁破壊電圧

皮膜種類	芯線	標準電導率（銅線100%）	絶縁破壊電圧 2個より法(JIS)
α アルミナ セラメッキ (15μm)	アルミ	60	320 V
	銅・アルミクラッド	76	
	銅・カーボン・アルミクラッド	77	
シリケート セラメッキ (15μm)	アルミ	60	310 V
	銅・アルミクラッド	76	
	銅・カーボン・アルミクラッド	77	

芯線径は、0.5、0.8、1.0mmは常時在庫があります。
上記以外の仕様も製作に応じております。

Outgassing data

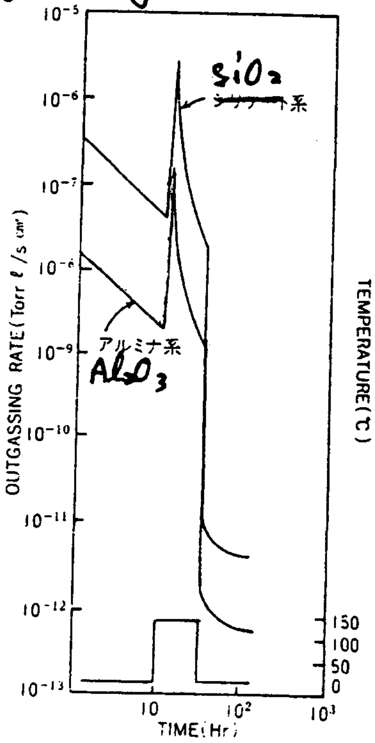

図1 セラメッキ”の超高真空特性

表2．銅芯電線の耐熱性

銅芯の場合、高温で使用すると次第に合金層が成長し電導率が低下してきます。下表は初期の電導率より10%低下するまでの予測期間です。

使用温度(℃)	200	250	300	400
銅芯・アルミクラッド	10年	2年	1000時間	
銅芯・カーボン・アルミ			2年	1000時間

- ・アルミ素材のボビンは「セラメッキ」処理で絶縁加工後セラメッキ電線を巻く方法が効果的です。
- ・高真空用特殊圧着端子も取り扱っております。
- ・上記各種データは保証値ではありません。

Fig. 8　　factory specs

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