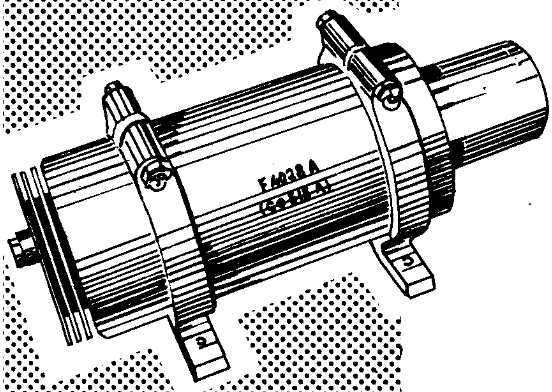
Carcinotron | F 4028 A (CO 515 A)



F 4028 A (CO 515 A)

1000 to 2100 Mc/s

WIDE ELECTRONIC TUNING BAND OSCILLATOR

The new "O" type Carcinotron F 4028A (CO 515A) is, due to a very high signal to spurious oscillation ratio, an oscillator which is specially suited for swept generators with a large frequency deviation, spectrum analyzers with a very wide spectrum, panoramic radar receivers, random frequency radars (transmitter drivers and local oscillators) etc.....

This tube, which is focused by an integral permanent magnet, delivers a power output of 100 (min) to 1 500 mW over the range 1 000 - 2 100 Mc/s. The frequency varies in a continous manner as a function of the anode 2 voltage (delay line and collector connected together).

Amplitude modulation and pulsed operation can be achieved by controlling anode 1 or grid voltage.

A great sturdiness and long life allow for the use of this tube in UHF equipments both industrial and military.

Weight : 8,3 kg(18 lbs)

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CSF COMPAGNIE GÉNÉRALE DE TÉLÉGRAPHIE SANS FIL

September 1963

GENERAL CHARACTERISTICS

ELECTRICAL CHARACTERISTICS

	Symbol	Values: nominal	Values: min or max	Unit
FREQUENCY :				
Minimum		1000	⩾ 980	Mc/s
Maximum		2100	⩽ 2200	Mc/s
OUTPUT POWER				
Minimum	P_o min	220	⩾ 100	mW
Maximum	P_o max	1200	⩽ 1500	mW
Power variation in the band	ΔP	7.5	⩽ 10	dB
Maximum variation over a 200 Mc/s band	ΔP	-	⩽ 3	dB
HEATING :				
Heater voltage	Vf	6.3	6.3 ± 0.3	V
Heater current.	If	2.0	⩾ 1.5	A
			⩽ 2.6	A
APPLIED VOLTAGES :				
Cathode to anode 2 voltage				
at f = 1000 Mc/s.	Va2	180	⩾ 150	V
at f = 1500 Mc/s.	Va2	455	-	V
at f = 2100 Mc/s.	Va2	1105	⩽ 1400	V
Tube to tube variation of anode 2 voltage for identical frequencies. . .	Δ Va2	-	⩽ 5	%
Max anode 2 current(at f = 2100Mc/s)	Ia2	48	⩽ 70	mA
Min anode 2 current(at f = 1000Mc/s)	Ia2	27	⩾ 15	mA
Max anode 1 voltage	Va1	indicated on each tube.	⩽ 150	V
Min anode 1 voltage	Va1		⩾ 40	V
Max anode 1 current	Ia1	-	⩽ 7.5	mA
Grid voltage	Vg	0	⩾ -125	V

	Symbol	Values nominal	Values min or max	Unit
THERMAL FREQUENCY DRIFT				
After 10 mn of operation	$\Delta f/f$	-	$\leqslant 10^{-3}$	-
FREQUENCY DRIFT UNDER PULSE OPERATION				
Between 100 and 500 µs after the beginning of the pulse and for a max frequency variation of 15 %. .	Δf	-	$\leqslant$ 35	kc/s
MODULATION :				
Sensitivity of frequency modulation by Va2				
min (f = 2100 Mc/s)	S	0.65	0.5	Mc/s/V
max (f = 1000 Mc/s)	S	2.6	2.75	Mc/s/V
Amplitude modulation by Va1 Va1 variation for an output power variation ΔP of 6 dB				
min.	Va1	-	8	V
max	Va1	-	80	V
Cut off grid voltage Vg min	Vg bl	-	- 100	V
CAPACITANCES :				
Grid to all other electrodes	Cg	20	< 40	pF
Anode 1 to all other electrodes . .	Ca1	18	< 40	pF
Anode 2 to all other electrodes . .	Ca2	30	< 50	pF
Filament to cathode	Cfk	15	< 30	pF
INSULATION RESISTANCES : (Vf = 6.3 V)				
Grid to all other electrodes (when grid to A1, A2 and k voltage is - 100 V)	Rg	100	> 1	MΩ
Anode A1 to all other electrodes (when anode A1 to g, A2, k voltage is - 300 V)	Ra1	100	> 1	MΩ
Anode 2 to all other electrodes (when anode A2 to g, A1, k voltage is - 1500 V).	Ra2	150	> 5	MΩ
Filament to cathode(when filament to k voltage is ± 50 V)	Rfk	9	> 0.05	MΩ

MAXIMUM RATINGS

	Symbol	Value min	Value max	Unit
Heater voltage	Vf	6.0	6.6	V
Filament starting current.	If peak	-	5	A
Cathode preheating time	tk	120	-	s
Grid voltage.	Vg	- 125	0	V
Anode 1 voltage	Va1	Vg1	200	V
Anode 2 voltage	Va2	Va1 + 10	1500	V
Anode 2 current	Ia2	-	70	mA
Anode 1 dissipation	Pa1	-	1.5	W
Anode 2 dissipation(with cooling).	Pa2	-	90	W
Voltage between filament and cathode	Vf/k	- 50	+ 50	V
Resistance to connect in parallel on the grid supply.	Rg	-	50	KΩ
Resistance to connect in parallel on anode 1 supply.	Ra1	-	50	KΩ

MECHANICAL CHARACTERISTICS

VIBRATIONS :

- Frequency 10 to 50 c/s - amplitude = 1 mm - maximum acceleration 10 g
- Frequency 50 c/s - acceleration 10 g

$\triangle$ f max = $\pm$ 0.5 Mc/s
$\triangle$ P max = $\pm$ 5 %

SHOCK :

Maximum acceleration 15 g - pulse length 11 µs

OPERATING POSITION : any

SURROUNDING CONDITIONS : see paragraph entitled "Focusing Device".

SURROUNDING TEMPERATURE :

- While in operation . . . . 100° C max
- While in stock . . . . - 65° C to + 110° C

COOLING :

- Temperature of the reference point T which should not be exceeded 150° C
- Cooling by forced ventilation air flow 10 dm3/s
  - air pressure : 2.5 g/cm2
  - air direction : area of the point of reference T

TYPICAL APPLICATION

	Unit	Symbol			
- Heater voltage	V	Vf	6.3		
- Heater current	A	If	2		
- Grid voltage	V	Vg	0		
- Anode 1 voltage	V	Va1	70		
- Operating frequency	Mc/s	f	1000	1500	2100
- Anode 1 current	mA	Ia1	1.8	1.35	1.25
- Anode 2 current	mA	Ia2	27	37	48
- Anode 2 starting current	mA	Ia2 acc	5	15	33
- Anode 2 voltage	V	Va2	180	455	1105
- Output power	mW	P_o	220	760	1150

- Operating frequency	Mc/s	f	1000	1500	2100
- Modulation sensitivity by anode 2 (measured with Va2 from 50 to 100 V)	Mc/V	S	2.6	1.3	0.65
- Modulation by anode 1 : variation of Va1 to reduce output power P_o by 6 dB	V	$\triangle$ Va1	-34	-30	-19
- Grid cut off to stop oscillations	V	$\triangle$ Vg	-45	-34	-20
- Frequency pushing when P_o is reduced from 6 dB by action on Va1	Mc/s	$\triangle$ f	25	20	13
- Frequency pulling when the phase load with VSWR = 1.5 varies by ± 180°	Mc/s	$\triangle$f	5.2	1.6	1.5
- Signal to spurious oscillation measured on the spectrum analyzer(between 0.1 and 10 Mc/s from the carrier)	dB	S/B	> 50	>50	> 50
- Signal to noise ratio(kTB for intermediate frequency of 30 Mc/s is equal to - 174 dBm/c/s, P_o = 1 mW	dB	N/kTB	< 20	<20	<20
- Vibrations 1 to 50 cs - amplitude = 1 mm(10 g max)					
Max frequency variation	Mc/s	$\triangle$ f	± 0.1	± 0.1	± 0.1
Max power variation	%	$\triangle$P	± 0.5	± 0.5	± 0.5
- Sensitivity to the surrounding magnetic conditions(see focusing device)					
Ferro-magnetic material(10 cm or 4'' away)	%	$\triangle$P	0.3	1	3
Magnetic devices(15cm or 6''away	%	$\triangle$P	1	3	8
- Actual operating range	Mc/s	f	940 ---------- to ---------- 2300		
	mW	P_o	190 ---------- to ---------- 1100		
- Max power variation :					
1° - over the 1000 - 2100 Mc/s range	dB	$\triangle P_o$		7.5	
2° - over any band 200 Mc/s wide	D	$\triangle P_o$		2.6	

NOISE AND SPURIOUS OSCILLATIONS IN THE RF SIGNAL

It is well known that spurious oscillations due to the presence of ions in the electron beam of klystrons, TWT, Carcinotrons, etc... bring about frequency modulation in the RF signal.

The recent studies performed at the CSF laboratories brought an efficient solution to this problem, requiring no cumbersome devices such as ion pumps.

SPURIOUS FREQUENCY MODULATION:

fm > 0.05 Mc/s

When the beam current of a carcinotron is modulated by spurious oscillations(modulation frequency between 0.5 and 5 Mc/s), the signal to spurious oscillations ratio, as seen on a spectrum analyzer, is lower in the case of frequency modulation than in the case of amplitude modulation. This is due to the high value of the pushing factor. Thus, the spectrum analyzer will chiefly display the spurious frequency modulation of the signal.

The following table gives the values of the signal to spurious oscillations ratio seen between 0.05 Mc/s and 1000 Mc/s on either side of the carrier

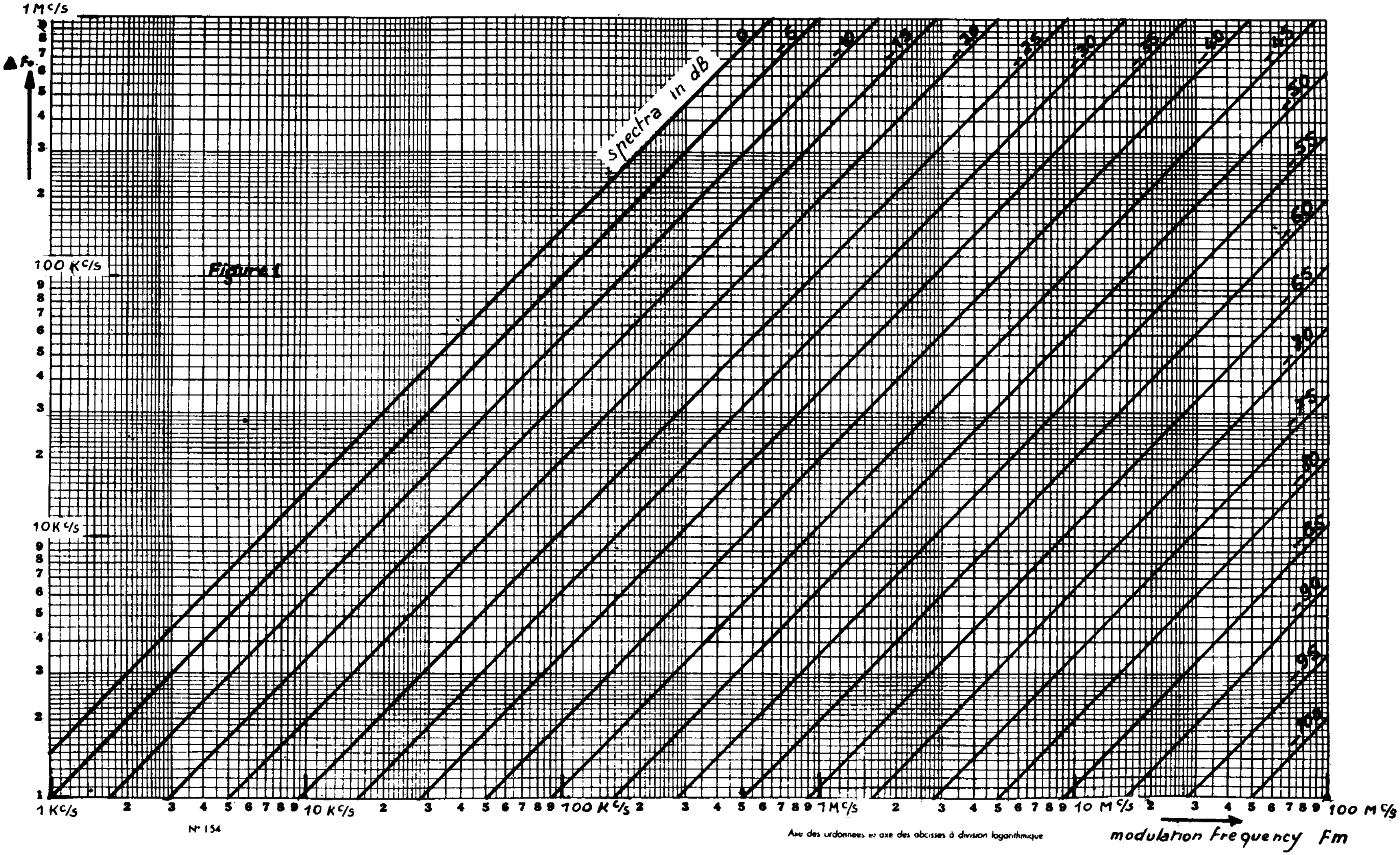
Frequency band investigated on either side of the carrier (Mc/s)	Signal to spurious oscillations ratio for any frequency in the F 4028A(CO 515A) range
	Values obtained (dB)
± 0.05 to ± 0.2	⩾ 35
± 0.2 to ± 10	⩾ 45
± 10 to ± 1000	⩾ 50

The chart (figure 1) gives the values of Δf as a function of the modulation frequency fm, for various of the ratio $\frac{J1\,(m)}{Jo\,(m)}$ and specifies the limits of the measurement - $m = \frac{\Delta f}{fm}$

Jo = carrier modulus
J1 = 1st ray modulus at ± 1 fm from the carrier
m = modulation index
Δ f = frequency deviation
fm = modulation frequency

SPECTRA in FREQUENCY MODULATION

$$\frac{J1m}{J0m} \text{ in dB} \quad m = \frac{\Delta F_0}{F_m}$$



It must be pointed out that this method is not sensitive enough to measure the signal to white noise ratio and that the figures given in the above table apply only to spurious oscillations.

The oscillogram (figure 2) shows that a spectrum obtained with a current production tube.

<u>fm < 0.05 Mc/s</u>

In this case, the standard spectrum analyzer cannot be used. The frequency modulation can be measured with the help of a system including, for instance, a discriminator and à selective voltmeter. This measurement, contrary to the preceding one, cannot be made continuously all over the carcinotron band and furthermore requires much care and precautions. A panoramic method, utilizing a wide band spectrum analyzer (1.4 Mc/s at 3 dB points instead of 12 Kc/s) allows the measurement of $\triangle f$ by measuring the thickness of the curve on the scope (see figures 3, 4 and 5). This method, the sensitivity of which is low(the minimum measurable $\triangle f$ is about 50 Kc/s), can be applied on all production tubes so that tubes having relaxation phenomena at very low frequency can be eliminated.

Thus, a guarantee on the maximum value of $\triangle f$ ($\leqslant$ 50 Kc/s) in the band $\pm$ 0.05 Mc/s, on either side of the carrier, can be ascertained.

The oscillogram (figures 3, 4 and 5) show the results given by a normal tube and by two very defective tubes.

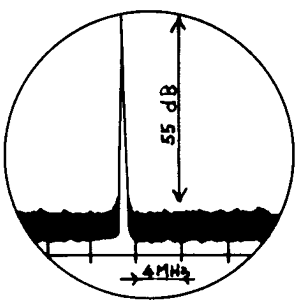


Fig. 2

Oscillogramm observed on a spectrum analyzer

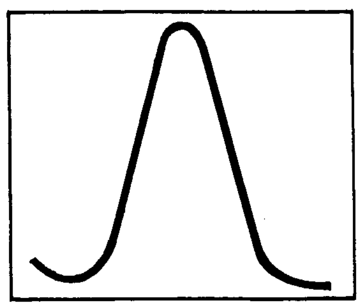


Fig. 3

$\triangle f \leqslant 50$ kc/s, pure spectrum, normal tube

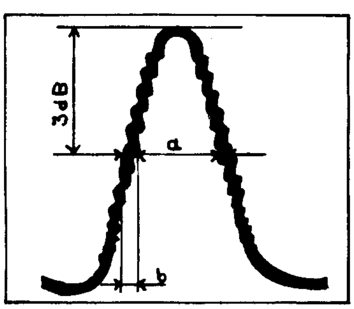


Fig. 4

fm $\simeq$ 5 kc/s,
$\triangle f = 1,400 \times \frac{b}{a} \simeq 150$ kc/s
obvious defect

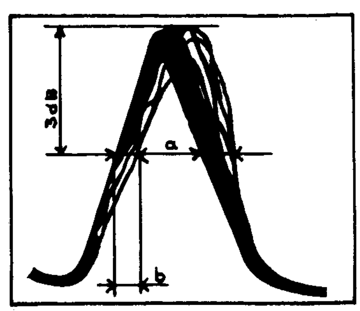


Fig. 5

fm = 35 c/s,
$\triangle f = 1,400 \times \frac{b}{a} = 300$ kc/s
obvious defect

SPURIOUS AMPLITUDE MODULATION:

As mentioned above, the carrier to spurious signal ratio is larger in the case of amplitude modulation than in that of frequency modulation. A more sensitive method than the spectrum analyzer must therefore be used but unfortunately it cannot have the advantage of being panoramic.

We can express the quality of the carcinotron by the signal to noise (or spurious oscillations) ratio per cycle or by the noise (or spurious oscillation) to kTB ratio.

Let us recall that kTB for T = 290° K and B = 1 c/s is equal to - 174 dBm

From the example given on figure 6, we can write :

- Signal/noise = $\frac{a}{b}$ $\longrightarrow$ 154 dBm or noise/kTB = $\frac{b}{c}$ = 20 dBm

The results are found when a klystron is substitued for the carcinotron in the measurement system.

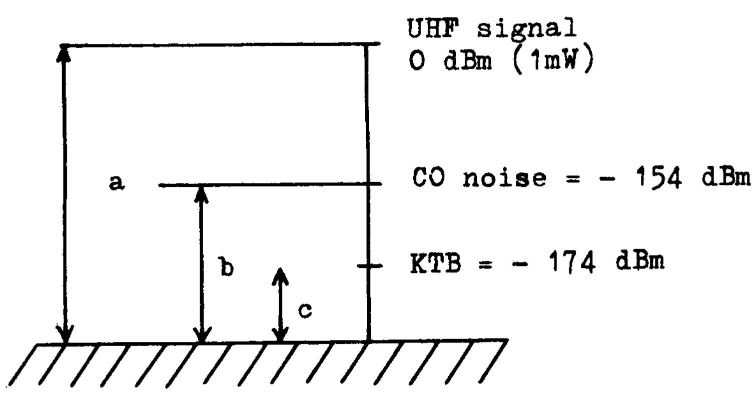
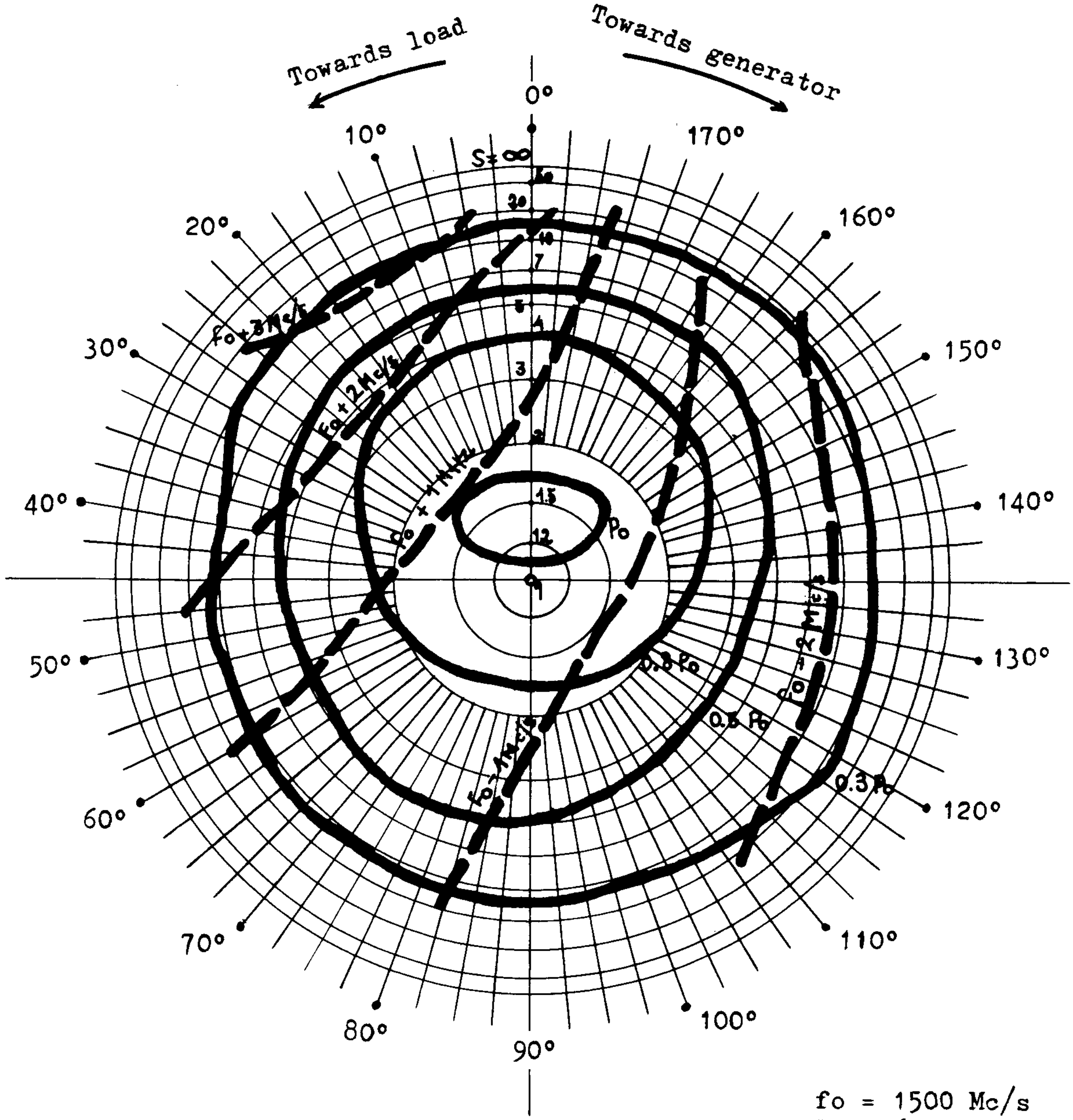


fig.6

LOAD:

The Rieke diagram given by way of example(figure 7) shows that the carcinotron F 4028A (CO 515A) will oscillate even under conditions of high-VSWR and varying phase.

However, it can be seen that a strongly unmatched load will make the frequency very sensitive to the phase and will substantially reduce the power



fo = 1500 Mc/s
Po = 650 mW

Figure.7

FOCUSING DEVICE - MAGNETIC SPACE FACTOR :

Magnetic focusing of the electron beam is achieved by means of eight magnetized parallel bars of Ticonal 800 bearing at their ends on two pole pieces. The tube location is adjusted for the optimum position with respect to the focusing device and fastened to it. This adjustement must never be altered. Any accidental misadjustement or demagnetization of the focusing device might cause back of oscillation over a part of the range and or spurious modulation of the signal.

TWO IMPORTANT RECOMMENDATIONS :

1°) In order not to demagnetize the focusing device (which could put the carcinotron out of use) do not stick either ferromagnetic objects on the magnet, or another magnet. In order to prevent excessive distorsions of the magnetic field, keep all ferromagnetic objects at least 10 cm (4 inches) away from the tube. Keep all apparatus producing magnetic fields 15 cm (6 inches) apart from the focusing device.

2°) Do not forget that the leaking of the focusing device can disturb the operation of devices such as electron tubes, measuring devices, relays, etc... if these are located too close to the carcinotron. For this purpose (figure 8) will give the magnetic "bulk" of the F 4028A (CO 515A) for ferromagnetic and magnetic parts as well as the values of the leakage field at the typical points of the magnetic "bulk" so defined.

NOTE :

The carcinotron sensitivity to magnetic environment is checked in the following ways :

1°) <u>Ferromagnetic parts</u> : they are simulated by a sheet, 2 mm thick, the sides of which are respectively 250 and 350 mm. This sheet is moved at a constant distance (10 cm = 4 inches) around the carcinotron and for its most unfavorable position, the maximum power variation caused by its presence is recorded.

2°) <u>Magnetic field generating devices</u> : they are represented by a magnet consisting of four coupled elements of 15 x 26 x 190 mm of Ticonal 800 which corresponds to a leaking field on the axis of about 37.10^{-4} and 15.10^{-4} T (37 and 15 oersteds) at distances of 10 and 15 cm from the end of the bar respectively.

As previously, the bar is moved around the carcinotron at a constant distance of 15 cm (6 inches) and in its most unfavorable position and orientation the maximum power variation caused by the magnet is recorded.

NOTES ON HANDLING AND INSTALLATION

As mentioned in paragraph "Focusing Device" the tube can be damaged if certain precautions are not taken. The chances of damaging the carcinotron will be reduced by complying with the following instructions :

1°) Keep the tube in its package until it is to be used.

2°) Use preferably non-magnetic tools (spanner, screw-driver) or, if impossible, avoid "sticking" the tools on the magnet. The package contains a non-magnetic alloy screw-driver.

FASTENING :

- Use four screws made of non-magnetic stainless steel or brass, diameter 5 mm.

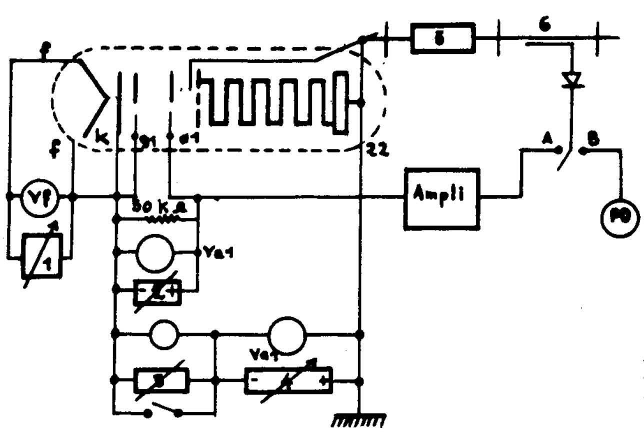
- Follow the instructions of paragraph "Focusing Device" as far as the distances between the carcinotron and surrounding materials are concerned.

CONNECTIONS :

- By structure, anode 2 is connected to the collector and to the focusing device. The positive terminal of the high voltage power supply must be connected to the pins 5 and 6 of the base(anode 2 and mass)

- Recommandations : do not forget to set the filament to cathode potential by connecting the terminals 1 and 2 or 2 and 7 if no voltage has to be applied between filament and cathode. Otherwise, let us remind that this voltage must not exceed ± 50 V.

CONNECTION DIAGRAM



1°) Filament supply, adjustable between 0 and 6.3 V stabilized at 5 x 10^{-2}
2°) Anode 1 supply
3°) Anode 2 modulation source
4°) Anode 2 supply
5°) Decoupling device
6°) Directional coupler and crystal

Nota - The cathode can if necessary be earthed but then the RF output the body of the tube must be insulated.
A : constant output power
B : output meter

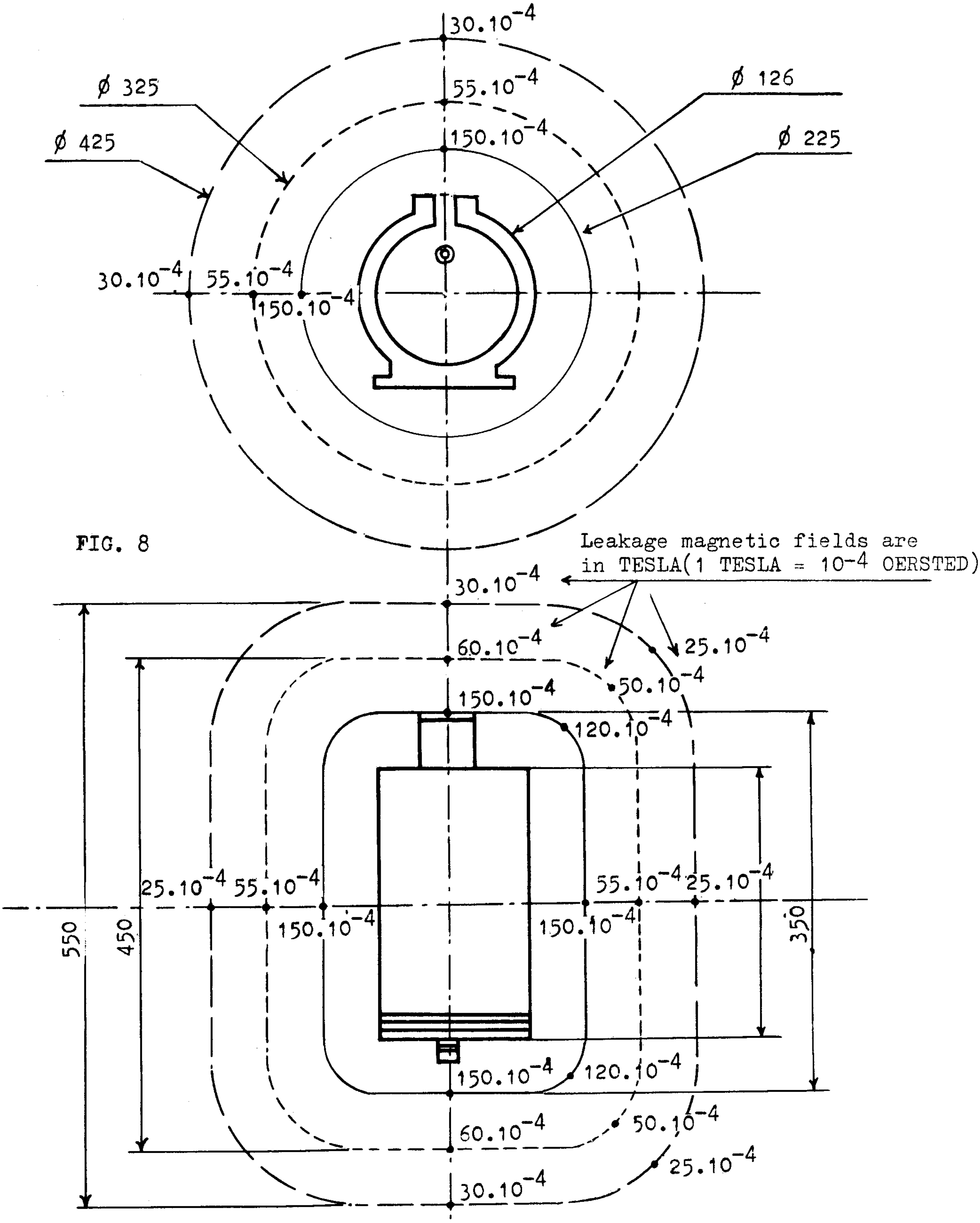


FIG. 8

———— minimum clearance tube kept for field generating devices
- - - - - " " " magnetic materials

NOTES ON STARTING AND STOPPING

STARTING:

1°) Start cooling
2°) Apply heater voltage 6.3 V, wait for 120 s
3°) Apply grid voltage(if necessary)
4°) Apply anode 2 voltage
5°) Apply anode 1 voltage

STOPPING:

Follow reversed order.

RECOMMENDATIONS:

1°) The anode 2 voltage must never be lower than the anode 1 voltage, even when modulated.
2°) During initial starting operation, apply reduced voltages such as :

$Va2$ = 400 V
$Va1$ = Value shown on the carcinotron serial plate 10 to - 20 V

Ascertain that the tube is operating normally before applying the normal voltages.

POWER SUPPLIES

HEATER:

1°) The filament starting current should not exceed 2.5 times the nominal value.
The cold resistance of the filament is about 0.3 Ω
2°) It is very advisable to use d.c. source to heat supply. Indeed, use of a.c. supply causes a frequency modulation at 50 c/s and the frequency deviation Δf can reach several hundreds of kc/s.

- <u>Grid and anode 1 power supply</u>

It is necessary to shunt these power supplies with a resistance of 50 kΩ in order to maintain the values of Vg and $Va1$ voltages, in the eventual case of reverse currents in these electrodes.

- Insulations

By structure, the positive terminal of the high voltage supply is connected to the outside envelope of the tube which is usually grounded. Do not forget that the cathode, the filament, the positive terminal of the power supply of the grid, the negative terminal of the anode 1 power supply may thereby be brought to a negative potential of 1500 V with respect to the ground. The power supplies insulations will therefore have to withstand this voltage.

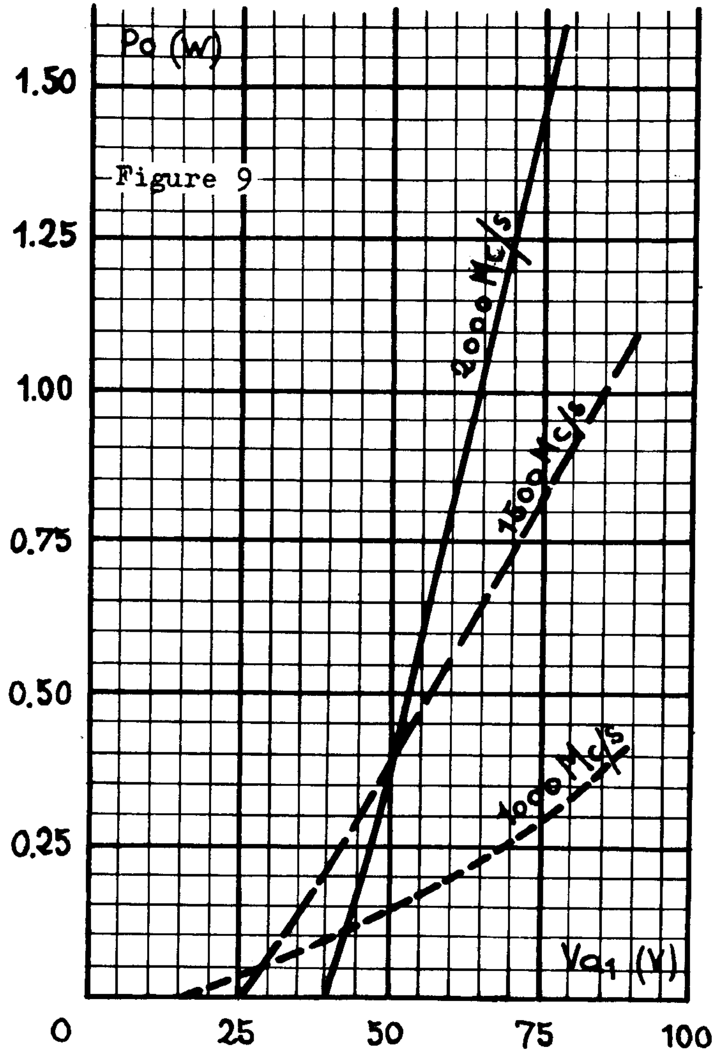
- Regulation of the power supply voltages

Heater voltage : regulated $\pm$ 5 %

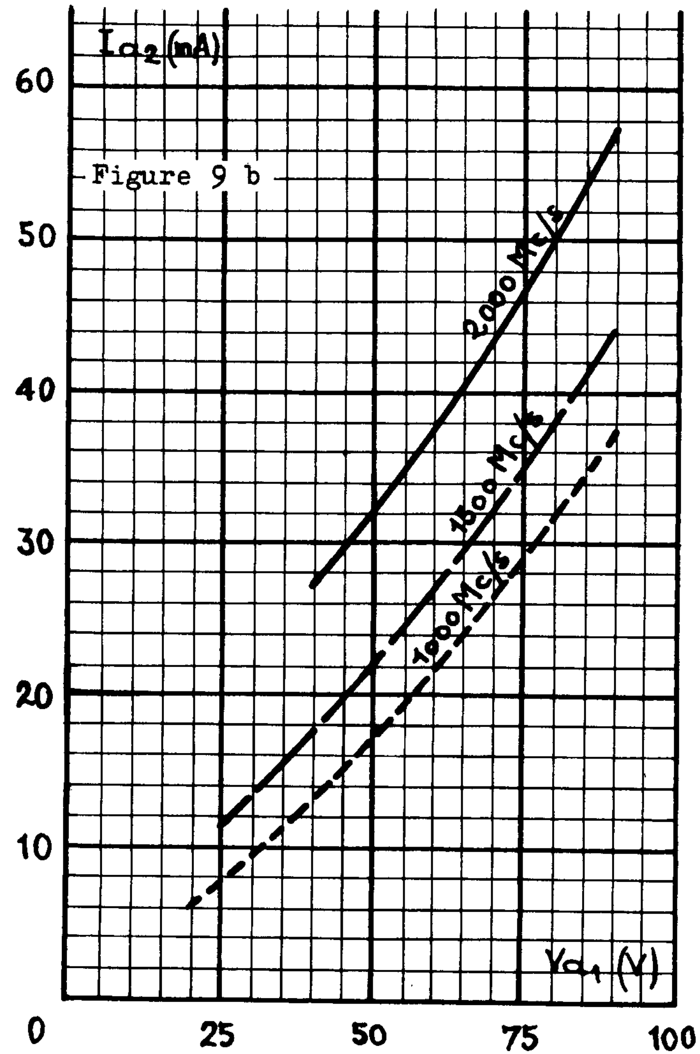
Other voltages : the values indicated previously in the typical operation example and the curves giving P_o and Ia2 variations as functions of Va1 and Vg enable the user to define the stability required for every voltage once he knows how stable the output signal should be.

FIGURES

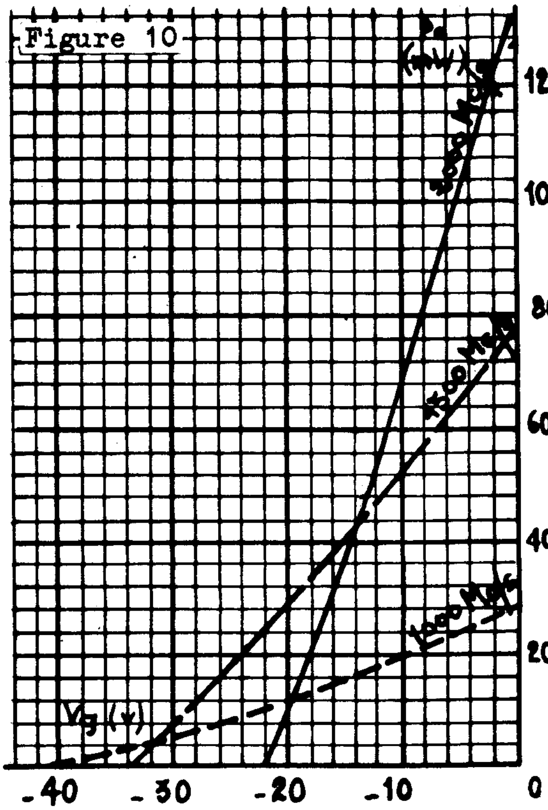
- Figures 9 and 9 b show respectively P_o and Ia2 variations as functions of anode voltage Va1.
- Figures 10 and 10 b show respectively P_o and Ia2 variations as functions of grid voltage Vg.
- Figure 11 shows the currents Ia2 and Ia1 variations as functions of the frequency, Va1 remaining constant and Vg being equal to 0.
- Figure 12 gives the variation of Va2 and P_o as functions of the operating frequency.



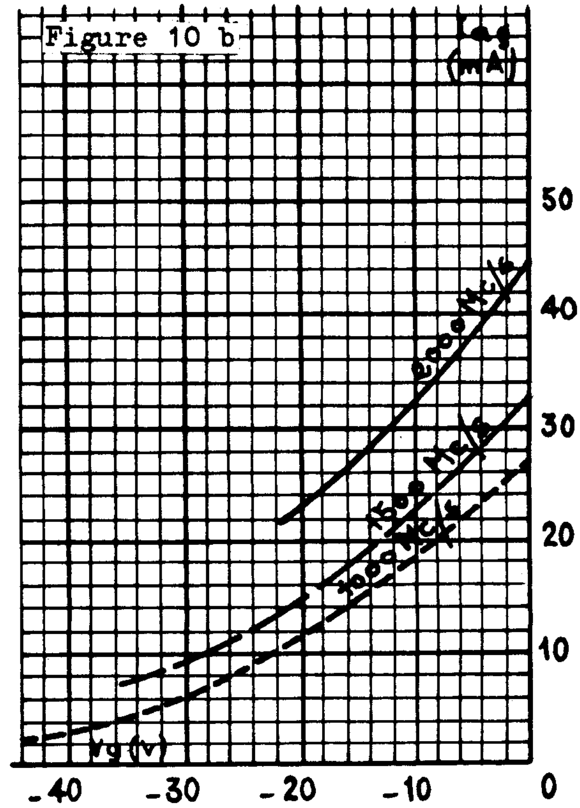
POWER VARIATION AS A FUNCTION OF Va 1



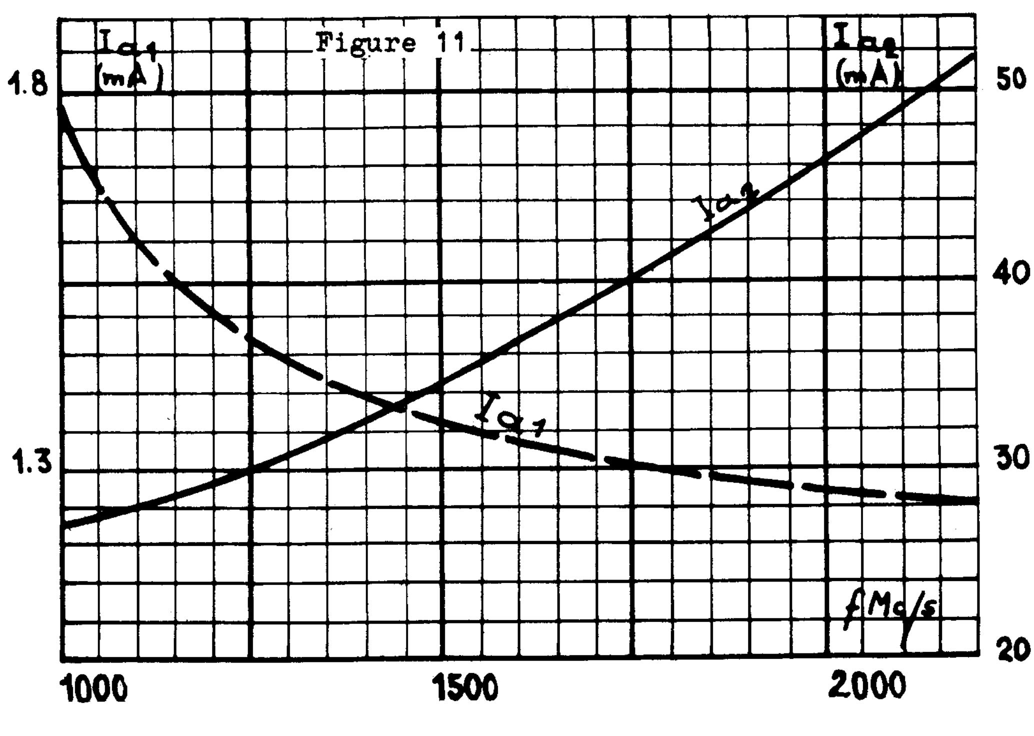
Ia 2 VARIATION AS A FUNCTION OF Va 1



POWER VARIATION AS A FUNCTION OF V_g

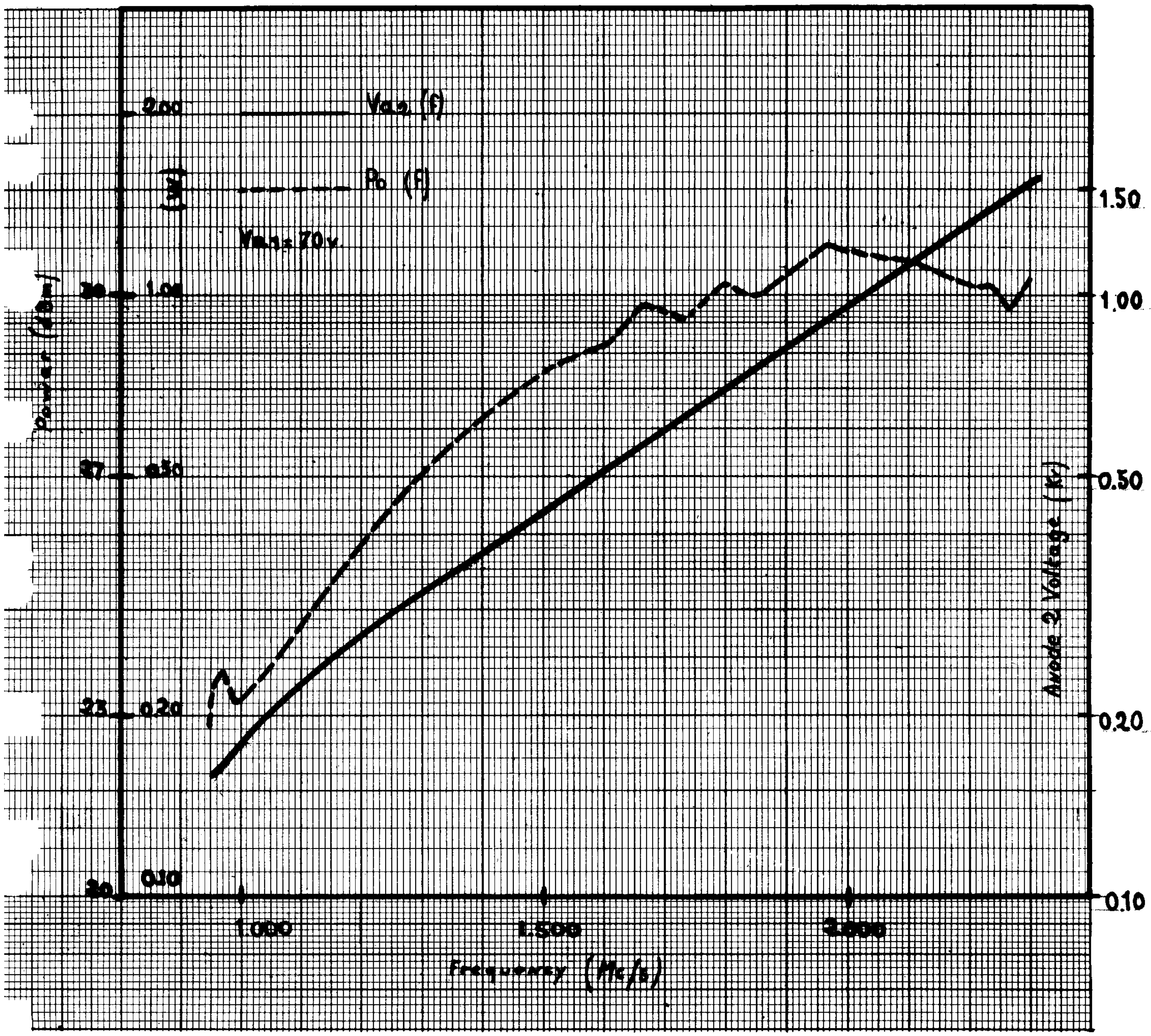


Ia 2 VARIATION AS A FUNCTION OF V_g

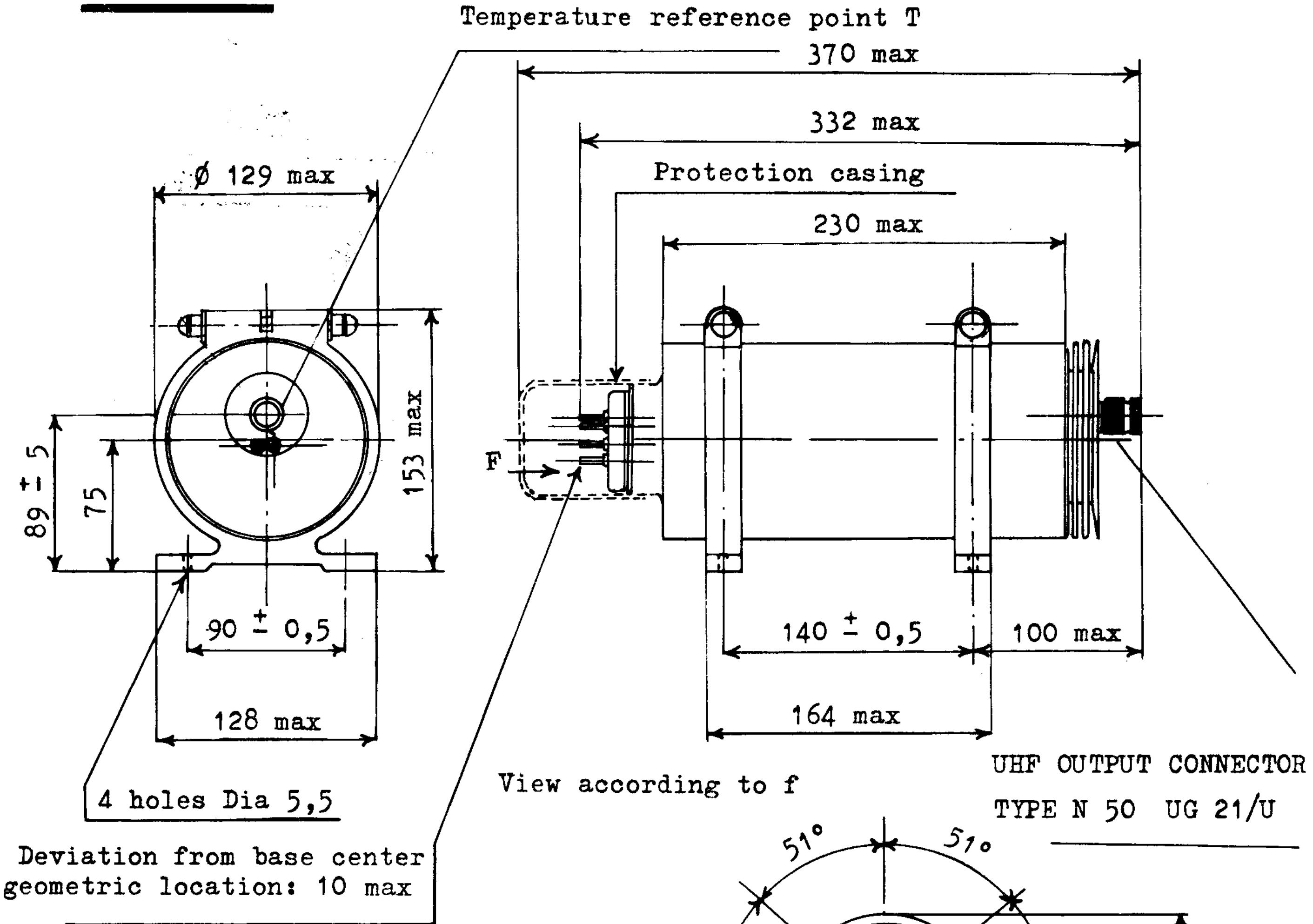


Ia1 AND Ia2 VARIATIONS AS FUNCTIONS OF FREQUENCY

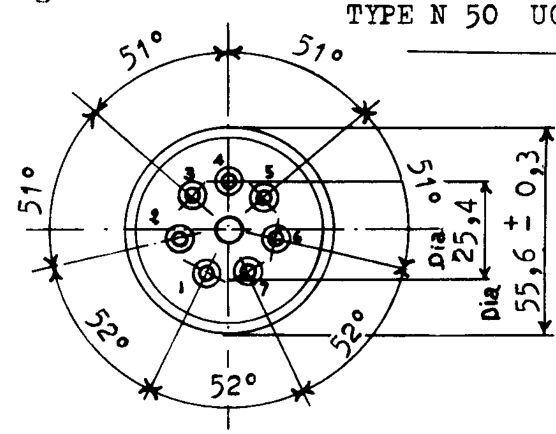
POWER Po AND LINE VOLTAGE Va 2 VARIATIONS VERSUS FREQUENCY



OUTLINE



View according to f



1 Filament
2 Cathode
3 Anode 1
4 Grille 1
5 Anode 2 and casing
6 Anode 2 and casing
7 Filament

Pins { ○ Dia 3,17 ± 0,08
● Dia 3,96 ± 0,08

Maximun tolerance in angular location of the base 15°

Max weigh 9 kg (20lb)
Tolerance in pin location .2 mn
Nota: all dimensions are in millimetres

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