214-0110-01-01_00

RF Note 109

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October 1990

Operating Characteristics of the K1200 RF Amplifiers Utilizing the Thomson TH555 Tetrode.

Contents.

1. Introduction

The K1200 amplifiers were redesigned to utilize the Thomson TH555 tubes in the final stage. This note describes some of the initial turn-on characteristics and bias conditions for these tubes. A description of the amplifier design is given in RF Note 108. In addition this note is meant to serve as a record of current tuning data such as variable capacitor servo calibration points. Also included in this note is a parts list contained in the appendix.

Within this note the individual tubes are referred to separately because their characteristics vary. Below is a list of the tube's designation for this note, and its present location:

Tube #	Location
1	A Transmitter
2	B Transmitter
3	C Transmitter
4	Spare (originally conditioned in A Transmitter)

2. Tube Conditioning.

Each TH 555 was slowly brought up to power then submitted to additional conditioning. The bias points chosen for initial turn-on are discussed in a later section of this note. Some instabilities were expected to exist during the initial hours of testing, and would disappear after proper tube conditioning. The focus at this point was to decide the most efficient way to achieve conditioning

Frequent crowbars of the final anode power supply took place during initial operation, with a large majority occurring when the Aydin P.S. (final anode) was turned off i.e. another system would shut down requiring the final anode P.S. to turn off also. The Aydin crowbar circuitry would trigger whenever the supply was commanded to turn off, due to overly sensitive dI/dt pickups detecting a transient when the supply shut down. The actual cause for shutdown of the final anode supply was often due to final screen overcurrents crowbarring the DA-2 P.S. (final screen, driver anode). The crowbar of this power supply then caused the Aydin to turn off via a command from interlock logic. The nature of these final screen crowbars is discussed in the following paragraph. It should be noted that these events are separate from crowbars due to neutralizer adjustment experiments.

During initial operation it was noted that a sawtooth modulation of the RF occurred under various conditions. This sawtooth is similar to that attributed to the neutralizer circuit which is discussed later. The sawtooth form of the modulation indicated that some sort of relaxation oscillation was occurring. At times we could trigger to the sawtooth modulation and it would appear quite stable when its magnitude was a small percentage of the total RF peak voltage.

When final screen overcurrents occurred we assumed that the scale of the sawtooth increased suddenly pushing the tube into the Emin region during the peaks of the sawtooth. The screen current drawn during these brief sections of the sawtooth modulation would not be visible on the final screen P.S. current meter, but may have still have triggered the overcurrent circuitry

An effort to limit the tubes ability to overcurrent was attempted by limiting the filament's emission. Nominally the filament runs at 350 A, 15 V so the filament was 'starved' by running at less than 10 V. This effectively hampers the tube's ability to overcurrent because a maximum drive signal on the grid does not produce a correspondingly large rise in anode or screen current, due to reduced electron emission. Even after starving the filament, however, we observed screen overcurrents.

At this point the final stage was tuned for maximum plate swing and efficiency by reducing the anode voltage to 10KV and increasing the plate impedance by adjusting the output coupler. The bias change made the relative difference between anode and screen much smaller, thereby increasing the efficiency considerably. Adjusting the coupler presented the anode with a high output impedance which resulted in a proportionally higher voltage on the anode. This high impedance, high efficiency configuration enhanced instabilities in the system.

Since the anode bias was lowered considerably a moderate drive signal could push the tube to its Emin point, causing the screen to draw current. The tube was run in this bias condition, increasing the drive until relaxation oscillation was visible on the anode. The modulation of the RF, however, would disappear after running for a period of time at a given power level. This exercise was repeated for successively higher screen currents until reaching 800mA of screen current with no sign of modulation. The tube was then returned to its normal bias condition and run without further instabilities.

The other tubes (1,2) were conditioned in this same way with equivalent results. It was not clear which process was responsible for the conditioning of the tube, or indeed what component of the tube actually needed the conditioning. Perhaps the process was due to conditioning the screen by heating it with higher currents, but this is only a guess.

3. Tube Bias Settings.

Initially all the tubes were biased with 1kV on the screen and the grids adjusted to give 1/2 Amp of anode current. These settings were used for the conditioning stage and preliminary testing. The resulting grid bias points are listed below:

Tube:	1	2	3	4
Grid Bias:	360	360	430	390

From this data it appears the tubes fall into two categories; low gain (tubes 1, 2) and high gain (tubes 3, 4).

All the tubes were operated at these set points for lower power levels without incident. However, when the power was increased problems became evident with the lower gain tubes because they began to draw grid current. This situation arises when the peak RF grid voltage equals the grid bias. Since we should not have reached this limit for these two tubes, it was decided to elevate the gain on all tubes by moving the screen voltage up to the next tap. This corresponded to a change from 1 KV to 1.2 KV. The operation of the two lower gain tubes improved, but instability problems occurred with the high gain tube. In retrospect, it is obvious we should not have increased the gain of tube 3 along with the others. This was soon realized and its screen voltage was returned to 1 KV. All the tubes are now set at 1/2 Amp quiescent anode current with the following bias voltages:

Tube-> X-mitter->	1 A	2 B	3 C
F. Grid	400	410	430
F. Screen	1200	1200	1000
F. Filament	13.5	13.5	13.5

4. Driver Screen Overcurrents.

Two of the transmitters suffered from frequent driver screen overcurrent indications, so a solution was sought for this problem. After analyzing the overcurrent trip signals along with the anode and screen currents during these events, it became clear that the overcurrents were real, not noise induced or due to faulty electronics. The overcurrents occur in closed loop for brief (< 10 mSec) periods when the RF system suddenly requires a large drive signal. The exact nature of this sudden demand for drive power is not clear, though it is always spurious in nature. The cause could be attributed to either (1) a sudden momentary decrease in dee voltage or (2) a change in the dee voltage monitoring devices which made it appear as if the dee voltage changed.

The nature of these overcurrents is assumed to follow a process as follows: (1) The system in closed loop requires more power. This could be due to one of the two situations above. (2) The driver anode and final grid voltages rise in response. (3) If at some point the sum of the final grid bias plus RF drive signal becomes positive, the final grid will begin sourcing current to the final grid power supply. Since this does not correspond to an overcurrent situation for the final grid supply, it will sink any current delivered to it without shutting down the system. (4) When current is being sunk in the final grid power supply, there will not be a corresponding rise in dee voltage. The feedback loop, therefore, still requires increased drive, and we return to the beginning of this loop. The above process will continue until the driver anode swings to Emin and causes driver screen overcurrents.

To preclude such overcurrents, the Voting Limiter module has a clamping circuit for the driver screens, though it was never properly calibrated. The crowbar/overcurrent circuitry is kept from triggering during these events by setting the Voting Limiter screen clamp to regulate at 75 mA., while the overcurrent protection circuit was left set to 400 mA. This change seems to have solved the problem.

5. Neutralizer Setting.

The neutralizers needed to be adjusted manually, for each transmitter due to variations each had in stray reactances. Originally the plan was to neutralize at 27 MHz so that all of the operating region would be over-neutralized. This was found to be undesirable since we discovered a region of over-neutralization in which the transmitter behaved as a relaxation oscillator. This in part was responsible for the relaxation oscillation during conditioning. The modulation was observed as a sawtooth wave (100 kHz < f < 500kHz) superimposed upon the RF waveform and appeared to be caused by the interaction between two elements: (1) the gain of the tube changing with drive signal, and (2) over-neutralization creating a significant negative feedback signal. The modulation would only occur for several small ranges of drive signal corresponding to a particular tube gain factor.

It was found there is actually a safe band of operation around the perfect neutralization point, so we avoided the unstable region by neutralizing in the middle of the frequency band (19MHz). The exact value of each neutralizing capacitor was decided by running the driver stage only and minimizing the voltage on the final anode. This corresponds in RF Note 108 to setting the voltage between node X and the Grid equal to zero (See Fig. B1, RF Note 108). Here we found that all the tubes could be neutralized at the same value, corresponding to approximately 3 pF.

Although the tubes are not fully neutralized at any frequency with this value, the effect of the internal feedback capacitance is reduced enough to prevent self-oscillation while also preventing relaxation oscillation due to the dynamic tube gain.

6. Servo Settings and Calibration.

Many of the servo systems had to be calibrated before a complete set of tuning data could be taken on the new transmitters. This section lists the servos and their calibration procedure.

<u>Driver Grid Inductor.</u>

At the high frequency end of our tuning range this inductance needs to be minimized. To achieve this the roller contact of the variable inductor was set near the end of the coil, leaving a small space to prevent contact with the mechanical limit. The servo was then set at its limit. The data below lists the servo setting at maximum frequency limit, and the distance from the roller contact to the end of the inductor coil.

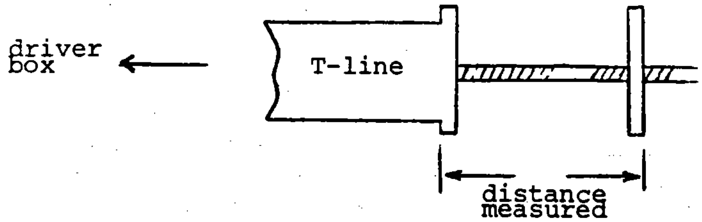
	<u>A</u>	<u>B</u>	<u>C</u>
Servo @ max. limit	895	894	881
distance left on coil	3/4"	3/4"	7/8"

<u>Driver Anode Inductor.</u>

Servos were all set to 500 and the distance from the transmission line flange to the travelling plate was measured. See figure for exact location of measurement points.

	<u>A</u>	<u>B</u>	<u>C</u>
distance	29 3/16"	29 5/16"	29 1/4"

Driver Anode Inductor Figure (Next Page).



Driver Anode - Final Grid Coupling Capacitor.

This element is a vacuum variable capacitor listed as C37 on the schematic. It has no servo motor attached since it remains the same value over the entire tuning range. With the intrinsic final grid capacitance, this capacitor forms a frequency independent voltage divider to adjust the voltage on the final grid. At peak driver anode swing there should be about 450 to 500 volts on the final grid. The capacitors were set by turning each in (CW) the same number of turns from the 'break-away' point. This is the point at which the adjustment axle unscrews from the base (all the way CCW) and occurs at maximum capacitance.

	A	B	C
turns	2.5	2.5	2.5

Driver Anode Capacitor.

All servos were set to 500 and the number of turns in from the break-away point was measured.

	A	B	C
turns	10 1/8	10 1/4	10 3/4

Final Stem.

These calibration points were taken from the tape measure connected to the sliding short with the servos set to 500.

	A	B	C
tape measure reading	28"	28"	31"

Output Coupler.

These vacuum variable capacitor settings were measured in the same manner as the previous capacitors. The numbers listed are turns in (CW) from the break-away point with the servo at 500.

	A	B	C
turns	12 1/2	12 1/4	13

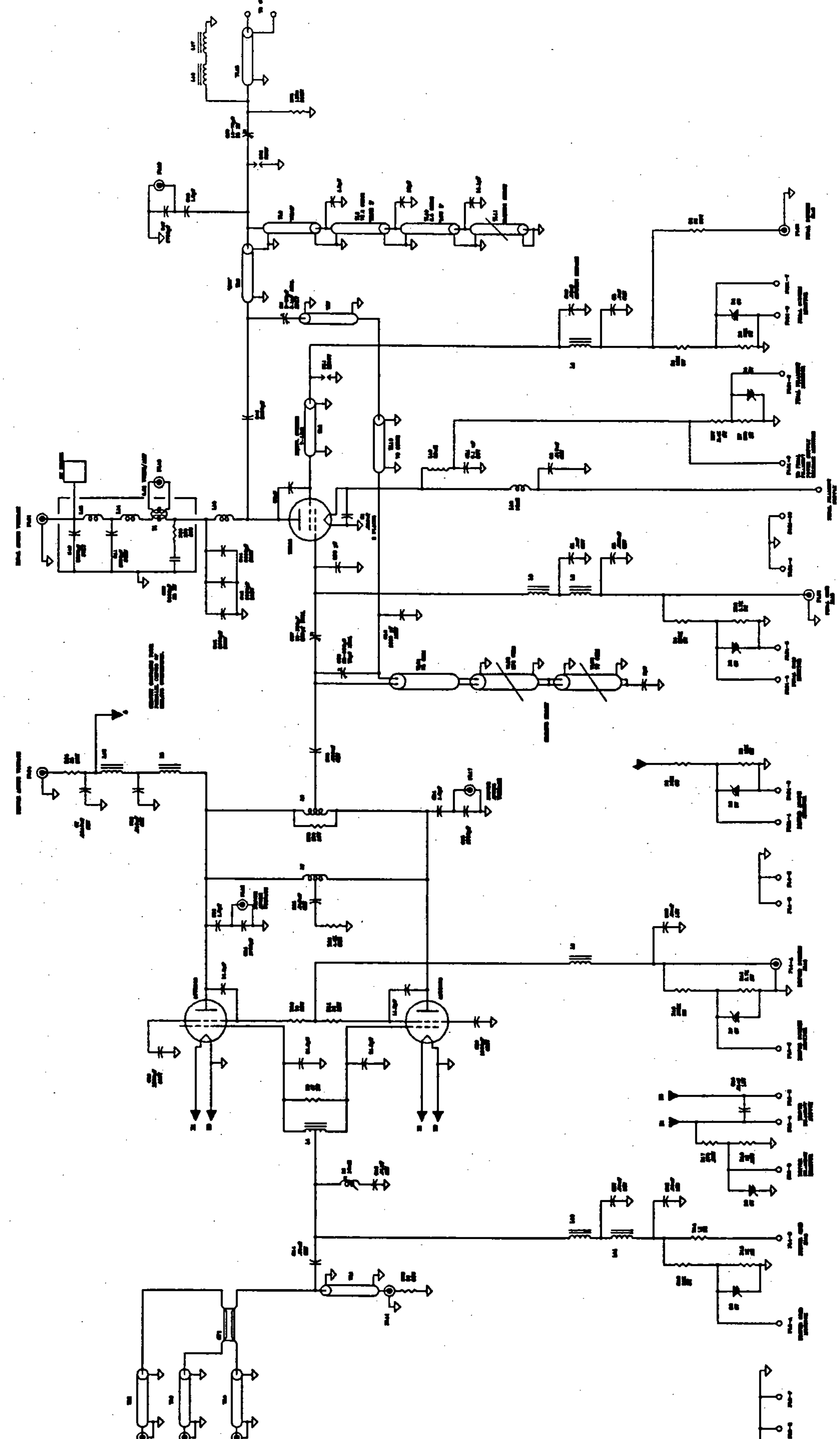
Neutralizer Capacitor.

The setting of these capacitors is described in detail in this note. The calibration data was taken as turns in from break-away. These settings are fixed for all frequencies.

	A	B	C
turns	21	21 1/8	21

Appendix B

Schematic and parts description.



K1200 RF TRANSMITTER PARTS 2/9/89

Item	Quantity	Reference	Part
1	2	C1,C26	.016uF SANGAMO AK25B163KN
2	1	C2	.002uF 6KV STK. PART
3	2	C3,C4	.002uF 3KV STK. PART
4	1	C5	62pF ANODE - SCREEN EQUIV. CAPACITOR
5	1	C7	.0068uF 5KV STK. PART
6	1	C8	2pF EQUIV. CAP.
7	4	C9,C25,C33,C39	.016uF 6KV SPRAGUE 1715CPP602HJ1632
8	1	C10	1000pF 15KV JENNINGS CFED-750-15S
9	1	C11	1.5pF EQUIV. CAP.
10	1	C12	18pF EQUIV. CAP.
11	1	C13	11.1pF EQUIV. CAP.
12	1	C14	1000pF 500V TRANS. CAP. DIST. BY SURCOM
13	2	C15,C17	81.5pF EFF. GRID-SCREEN + GRID-CATHODE CAP.
14	1	C16	.001uF 100V MICA STK. PART
15	2	C18,C19	.1uF 50V CERAMIC
16	7	C20,C21,C27,C28,C29,C30, C31	.01uF 500V STK. PART
17	2	C22,C32	11.8pF EFF. ANODE-SCREEN CAPACITANCE.
18	2	C23,C34	1.0pF EFF. CAPACITANCE REF. DWG. 8-RAT-11-E
19	3	C24,C35,C47	1700pF KAPTON FILM DWG. 8-RAT-8-69-B

Item	Quantity	Reference	Part
20	1	C36	20-500pF 70pF NOM. JENNINGS NO.CVDD500
21	1	C37	20-300pF 250pF NOM. JENNINGS NO.CVDD300
22	1	C38	800pF EFF. GRID-CATHODE + GRID-SCREEN CAPACITANCE.
23	6	C40,C41,C42,C43,C44,C52	3600pF 30KV SPRAGUE 362Z
24	1	C46	2000pF CERAMIC SLEEVE DWG. 8-RAT-8-E
25	1	C48	1.0pF EFF. CAPACITANCE HOUSING - CNTR CONDUCTOR DWG. 8-RAT-8-E
26	1	C49	.05uF SCREEN BYPASS DWG. 8-RAT-17-B
27	1	C50	10-75pF 55 KV
28	1	C51	10pF JENNINGS CFHD-10-455
29	1	CN	3-30pF 5.1pF NOM. 35KV
30	1	CP1	ANZAC CD-920-4 -20dB
31	7	D1,D2,D3,D4,D6,D7,D8	10V ZENER STK. PART
32	1	HV PROBE	FLUKE 80K-40HV
33	1	L1	6 TURN 18 AWG. ON INDIANA GEN'L CORE NO. F625-9-TC9
34	3	L2,L3,L4	22 TURNS 22 AWG. TEFLON WIRE ON 1.25" O.D. CORE INDIANA GEN'L NO. F626-12-Q1
35	3	L5,L9,L12	20 TURNS 22 AWG. TEFLON WIRE ON INDIANA GEN'L CORE F626-12-Q1
36	1	L6	10uH MULTRONICS NO.229-201-1
37	2	L7,L8	~0.1uH EQUIV. INDUCTANCE OF MECH. PART. DWG. 8-RAT-2-
38	2	L10,L11	25 TURN 22 AWG. TEFLON INSUL. WIRE ON INDIANA GEN'L F626-12-Q1 TOROID
39	2	L13,L14	12 TURNS .25" TUBE DWG. 5-RAT-11-D

Item	Quantity	Reference	Part
40	1	L15	20 TURNS .25" O.D. TUBE DWG. 8-RAT-17-29-D
41	1	L16	24 TURNS OF TUBING DWG. 8-RAT-14-E
42	1	L17	22-25 TURNS 18AWG. TEFLON WIRE ON INDIANA GEN'L F626-12-Q1 TOROID. DWG. 8-RAT-14-E
43	1	L18	10uH 10 TURNS .625" COPPER BAR DWG. 5-RAT-1-30-H
44	2	R1,R5	10M 3W DALE ROX-2
45	1	R2	1.2 3W STK. PART
46	1	R3	25K 3W STK. PART
47	1	R4	270K 2W STK. PART
48	1	R6	10K 2W STK. PART
49	1	R7	620 2W STK. PART
50	1	R8	40 5KW ALTRONIC 5705
51	2	R9,R21	47 2W STK. PART
52	2	R10,R11	50 25W OHMITE 270
53	1	R12	18K 1W STK. PART
54	3	R13,R14,R20	1K 1W STK. PART
55	2	R15,R18	500 .25W STK. PART
56	1	R16	1K .25W STK. PART
57	1	R17	270 .25W STK. PART
58	1	R19	98.5K 4W
59	1	R22	4.0K 5KW ALTRONIC 5705

Item	Quantity	Reference	Part
60	1	R23	250 10W GLO-BAR
61	1	R24	25 50W OHMITE L50J25R
62	1	R25	400 50KW ALTRONIC 5750
63	1	R26	50 50W BIRD TERMALINE MOD. 8085
64	1	R27	2.4K 2W STK. PART
65	1	R28	2.7K 2W STK. PART
66	4	R29	250 OHM 50W CARBORUNDUM
67	1	SG1	2500V VICTOREEN SGCA-1500
68	1	SG2	20KV DWG 8-RAT-8-E
69	1	T1	0.01 VOLTS/AMP ION PHYSICS NO. CM-1-5
70	1	TLD3	77 OHM DWG. 8-RAT-21
71	4	TL1,TL2,TL3,TL4	50 OHM RG223U
72	1	TL5	117 OHMS EQUIV. T-LINE OF SCREEN. L=.127 m
73	1	TL6	45.7 OHMS L=0.254 m DWG. 8-RAT-17
74	1	TL7	96 OHMS L~0.193 COAX. DWG. 8-RAT-17
75	1	TL8	45.7 OHMS L=0.102 m DWG. 8-RAT-17
76	1	TL9	72.2 OHMS L=0.3302 m DWG. 8-RAT-17
77	1	TL10	8.6 OHMS L=0.9296 m DWG. 8-RAT-17
78	1	TL11	125 OHMS L=0 - 0.2794 m DWG. 8-RAT-21
79	1	TL12	50 OHM 6.125" MYAT HARD LINE

Item	Quantity	Reference	Part
80	1	TLD1	75 OHM PARALLEL PLATE DWG. 8-RAT-20
81	1	TL13	70 OHM L=0.15 m EQUIV. PARALLEL PLATE DWG. 8-RAT-20
82	1	TLD2	178 OHM DWG. 8-RAT-21
83	2	TUBE1,TUBE2	4CW2000 RCA
84	1	TUBE3	TH555 THOMPSON

APPENDIX A. REPLACEABLE PARTS LIST

K1200 RF TRANSMITTER PARTS INVENTORY

# Nec.	Circuit Reference	Part	Vendor	Deliv.	Unit Price
3	C1	.016uF SANGAMO AK25B163KN	SANGAMO CORP. (803)878-6311	6 WK	20.00
3	C2,C4	0.1uF 5KV PLASTIC CAPACITOR CO.	NEWARK	2 WK	60.00
3	C3	.002uF 3KV CENTRALAB	NEWARK	1 WK	1.00
3	C7	.0047uF 5KV CENTRALAB	NEWARK	1 WK	1.00
6	C9,C25,C33,C39	.016uF 6KV SPRAGUE 1715CPP602HJ1632	SPRAGUE	2 WK	50.00
		or HIGH ENERGY EPSLU163ZS	RICHARDSON	2 WK	50.00
1	C10	1000pF 15KV JENNINGS CFED-1000-15S	SURCOM, BERNDT	6 WK	1400.00
6	C14,C16,C18,C27, C28,C29	0.01uF 1KV	SURCOM, NEWARK	1 WK	1.00
1	C36	20-500pF 70pF NOM. JENNINGS NO.CVDD500	SURCOM, BERNDT	6 WK	800.00
1	C37	20-300pF 250pF NOM. JENNINGS NO.CVDD300	SURCOM, BERNDT	6 WK	800.00
6	C40,C41,C42,C43,C44, C52	3600pF 30KV SPRAGUE 362Z	SPRAGUE	6 WK	50.00
1	C46	CERAMIC SLEEVE BLOCKING CAP	(MACHINED IN HOUSE)	-	-
1	C50	10-75pF 55 KV COMET CV3C75-N900	INMARK (203) 866-8474	6 WK	1500.00
3	C51	0.1uF 50V	NEWARK	2 WK	1.00
1	CN	3-30pF 5.1pF NOM. 35KV JENNINGS CAEC-30-35N785	SURCOM, BERNDT	6 WK	1000.00
1	CP1	ANZAC CD-920-4 -20dB	ANZAC (617) 273-3333	2 WK	100.00
6	D1,D2,D3,D4,D6,D7,D8	5V TRANZORB OR ZENER	NEWARK	2 WK	1.00
1	HV PROBE	FLUKE 80K-40HV	FULTON RADIO	2 WK	120.00
1	L1	6 TURN 18 AWG. ON 3/8" INDIANA GEN'L CORE NO. F625-9-TC9	INDIANA GENERAL	1 WK	5.00

3	L2,L3,L4,L9,L10 L11,L12,L17	22 TURNS 22 AWG. TEFLON WIRE ON 1.25" O.D. CORE INDIANA GEN'L NO. F626-12-Q1	INDIANA GENERAL	1 WK	5.00
3	L5	BAKER & WILLIAMSON AIR CORE INDUCTOR NO.3064 (MODIFIED)	BAKER & WILLIAMSON	2 WK	25.00
1	L6	10uH VARIABLE, MULTRONICS NO.229-201-1	MULTRONICS	6 WK	200.00
3	R1	10M 3W DALE ROX-2	NEWARK	2 WK	2.00
3	R2	25 3W	"	"	"
3	R3	25K 3W	"	"	"
3	R4	270K 2W	"	"	"
3	R5	10M 6W			
3	R6	10K 2W	"	"	"
3	R7	620 2W	"	"	"
3	R9	47 2W	NEWARK	2 WK	1.00
3	R10,R11	50 25W OHMITE 270	"	"	"
3	R12	20K 2W	"	"	"
3	R14	1K 1W	"	"	"
3	R15	1K 2W	"	"	"
3	R16	1K .25W	"	"	"
3	R17	270 .25W	"	"	"
3	R18	2.7K 2W	"	"	"
3	R19	270K 2W	"	"	"
1	R22	4.0K 5KW ALTRONIC 5705	ALTRONIC (800) 482-5623	6 WK	800.00
3	R23	250 10W GLO-BAR	CARBORUNDUM	4 WK	10.00
3	R24	25 50W OHMITE L50J25R	NEWARK	2 WK	2.00

1	R25	1250 50KW ALTRONIC 5750	ALTRONIC	6 WK	2000.00
1	R26	50 50W BIRD TERMALINE MOD. 8085	BIRD ELECTRONICS	2 WK	100.00
3	R27	2.4K 2W	NEWARK	2 WK	1.00
3	R28	2.7K 2W	NEWARK	2 WK	1.00
4	R29	250 OHM 50W 885 AS25KDS 8625	CARBORUNDUM	4 WK	10.00
1	SG1	2500V VICTOREEN SGCA-1500	VICTOREEN	6 WK	100.00
1	T1	0.01 VOLTS/AMP ION PHYSICS NO. CM-1-5	ION PHYSICS	6 WK	400.00
2	TUBE1,TUBE2	4CW2000 EIMAC	RICHARDSON	2 WK	2000.00
1	TUBE3	TH555 THOMSON	THOMPSON	2 WK	40000.00

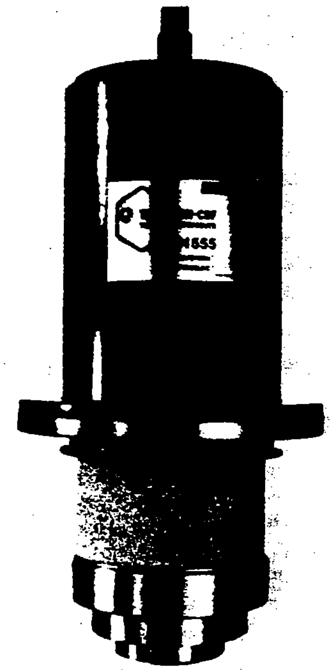
Appendix C. Initial Tuning Data for TH555

Freq. [MHz]	Trans-mitter	Driver Grid	Driver Anode C	Driver Anode L	Final Stem	Output Coupler	Input Coupler	Atten.	Upper Dee	Lower Dee
9	A	211	810	221	85	66	388	790	101	101
	B	150	810	204	81	60	382	833	103	103
	C	159	798	180	85	57	379	785	102	102
11	A	400	810	496	343	70	394	563	370	370
	B	388	810	484	347	57	408	576	369	369
	C	372	810	460	347	57	390	560	370	370
13	A	519	810	652	522	66	386	420	537	537
	B	524	810	644	522	57	376	444	536	535
	C	512	810	630	532	60	400	420	538	538
15	A	619	810	749	637	80	386	366	647	647
	B	617	810	743	633	80	352	367	646	646
	C	584	810	734	647	80	410	356	648	648
17	A	680	810	813	711	185	388	272	724	724
	B	686	810	810	712	185	442	284	722	722
	C	681	810	804	714	185	440	270	725	725
19	A	730	810	859	763	265	400	233	780	780
	B	711	810	857	760	265	391	238	778	777
	C	725	810	853	766	265	428	230	781	781
21	A	787	810	891	803	330	439	202	823	822
	B	795	810	889	802	330	409	203	820	819
	C	781	810	888	807	330	443	195	823	823
23	A	817	810	916	835	385	422	177	855	855
	B	834	810	914	835	385	413	177	852	852
	C	821	810	914	839	385	450	177	855	855
25	A	859	810	934	862	425	431	152	882	881
	B	868	810	933	862	425	419	158	878	878
	C	858	810	934	865	425	439	157	883	882
27	A	872	810	948	888	450	424	137	903	903
	B	901	810	947	877	450	407	145	899	899
	C	896	810	949	890	450	422	140	904	904

Appendix D

Tetrode data.

TH 555 HYPERVAPOTRON® TETRODE WITH PYROBLOC® GRIDS



- **Output power :**
  - **— 250 kW in LW and MW**
  - **— 200 kW in SW**
- **Operating frequency up to 110 MHz**
- **High gain**
- **High operation stability thanks to the Pyrobloc® grids**
- **Maximum anode dissipation 250 kW with Hypervapotron® cooling**

GENERAL CHARACTERISTICS

Electrical

Type of cathode	Thoriated tungsten
Heating	Direct, dc or single-phase ac
Heater voltage	Note (1)
Heating current, approx. (2)	320 A
Interelectrode capacitances, approx. :	
- cathode - control grid	245 pF
- control grid - screen grid	400 pF
- control grid - anode	4 pF
- screen grid - anode	62 pF
Amplification factor, average	4.8
Transconductance (Ia = 15 A, Vg2 = 1000 V)	220 mA/V

(1) Thomson-CSF defines the operating heater voltage according to each particular situation. See paragraph V : "OPERATING INFORMATION AND RECOMMENDATIONS".
(2) The indicated heating current corresponds to a heater voltage of 15 V. Both values are only approximate, allowing to choose the heater power supply.

Mechanical

Operating position	Vertical, anode up
Weight, approx.	38 kg
Dimensions	See the Outline Drawing

Anode Cooling

Type	Hypervapotron
Maximum anode dissipation, continuous	250 kW
Minimum corresponding water flow	110 l/min
Maximum water pressure at the input	5 bar
Maximum water temperature at the output	100 °C

Electrode Terminal Cooling

Type	Forced air
Cooling with TH 16110 connector :	
- minimum flow	1 m³/min
- corresponding pressure drop	12 mbar
Maximum temperature on the tube (ceramic seals and electrode terminals)	200 °C

RF AMPLIFIER OPERATION
ANODE MODULATION

(All potentials referred to cathode potential)

Maximum Ratings (5)

Maximum frequency	30	MHz
Anode voltage (6)	15	kVdc
Screen-grid voltage	1200	Vdc
Control-grid bias voltage	−800	Vdc
Peak cathode current	300	A
Anode dissipation	250	kW
Screen-grid dissipation	4	kW
Control-grid dissipation	1.5	kW

Typical Operation (carrier conditions)

	Ex. 1	Ex. 2	
Frequency	30	30	MHz
Anode voltage	11	14	kVdc
Screen-grid voltage	1 000	1 000	Vdc
Control-grid bias voltage	−550	−550	Vdc
Anode direct current	22.5	17	A
Screen-grid direct current	1.1	0.9	A
Control-grid direct current	1.1	0.9	A
Anode dissipation	48	38	kW
Screen-grid dissipation	1.1	0.9	kW
Control-grid dissipation	160	90	W
Output power (7)	200	200	kW

AF POWER AMPLIFIER

(All potentials referred to cathode potential)

Maximum Ratings (per tube) (5)

Anode voltage (6)	15	kVdc
Screen-grid voltage	1500	Vdc
Control-grid bias voltage	−800	Vdc
Peak cathode current	300	A
Anode dissipation	250	kW
Screen-grid dissipation	4	kW
Control-grid dissipation	1.5	kW

Typical Operation (values for two tubes)

Anode voltage	11	kVdc
Screen-grid voltage	1500	Vdc
Control-grid bias voltage	−400	Vdc
Anode direct current	2 x 20	A
Screen-grid direct current	2 x 0.4	A
Control-grid direct current	0	A
Anode dissipation	2 x 65	kW
Output power (7)	2 x 155	kW

---

(5) Absolute limiting values. No one value to be exceeded, even under transient conditions. Operating at more than one limiting value at the same time may cause tube damage.
(6) This maximum rating is indicated only for the type of operation considered. For other applications, consult us.
(7) Without taking circuit losses into account.

OPERATING INSTRUCTIONS

I - TRANSPORTATION, HANDLING AND STORAGE

I.1 - Receipt of the Tube

- *Checking the Tube in its Packing*

Upon receipt of a tube, without removing it from its container, check for any damage which may have occured during transportation. It is necessary :

- to inspect the inside and the outside of the container ;
- to check the tilt detector(s) and chock detector whenever provided on the container ;
- using an ohmmeter, test the continuity of the filament and the absence of short-circuits between the electrodes.

For the Hypervapotron® tubes, this operation can be carried out without taking the tube out of its packing crate.

- *Checking the Tube out of its Packing*

The high power Hypervapotron® cooled tubes are delivered mounted on a stand to ensure protection of the tube during storage :

- using a lift attachment (Figure 14), remove the tube and the stand ;
- verify that the tube does not have any traces of shocks ;
- using a trolley with pneumatic wheels, move the tube and the stand close to the transmitter tube socket avoiding shocks.
- following the directions of paragraph IV.3 "First Use", install the tube.

- *In Case of Damage*

Refer to the instructions on the back of the delivery statement in the "Documents" envelope on the packing case and send a letter listing claims to the last shipper immediately.

I.2 - Storage

The tube must be stored in a dry, dust-free place in a vertical position, either in the container or on the stand for the high power Hypervapotron® cooled tubes.

The tubes are delivered with removable ceramic protectors which must stay in place during storage. Tube ceramics must be kept clean. Never use an abrasive or a metal pad to clean them.

II - COOLING

II.1 - Hypervapotron® Anode Cooling

As for other Hypervapotron® tubes, the TH 555 is delivered with its water jacket in place, and with the water inlets and outlets marked ("IN" and "OUT" and with colors BLUE for inlet and RED for outlet). The incoming cooling water must always be connected to the inlet and the outgoing hot water must always be evacuated from the outlet. The connections are shown in Figure 10. The cooling water must be demineralized but not degassed and have a typical resistivity at 20 °C of 500 k Ω. cm. It should be verified that this resistivity remains at all times greater than 100 k Ω. cm using readily available instruments. The cooling water must be well filtered, to eliminate any solid materials and to avoid blockage of any cooling passages, as this would immediately affect the cooling efficiency and could produce localized anode overheating and failure of the tube.

Protection devices must be provided for the input pressure, water temperature and water flow, and connected to tube protection circuits.

II.2 - Electrode Terminal and Ceramics Cooling

It is necessary to cool the ceramic insulators and the electrode terminals. The electrode terminals and the ceramics are cooled by filtered forced air. The air flow must be carefully channeled in order to effectively cool the seals and the electrode terminals. The use of Thomson-CSF connectors for this purpose is recommended.

The temperature of both the ceramic insulators and the ceramic metal seals should be kept below the maximum value of 200 °C, since this is the controlling and final limiting factor for the tube. This temperature can be checked using temperature-sensitive paint, before the equipment design and air-cooling arrangements are finalized.

An air flow and pressure protection device should be provided at the terminal inlet.

The cooling of the tube electrode terminals requires a maximum air inlet temperature of 45 °C.

IMPORTANT

ALL COOLING MUST BE APPLIED BEFORE OR SIMULTANEOUSLY WITH THE APPLICATION OF ELECTRODE VOLTAGES AND SHOULD NORMALLY BE MAINTAINED FOR AT LEAST THREE MINUTES AFTER ALL VOLTAGES ARE REMOVED, TO ALLOW FOR TUBE COOL-DOWN.

III - HEATING

III.1 - Verification Before Installation

Before putting a tube into service, check with an ohmmeter that the cathode heater is undamaged and for the absence of contact between the electrodes.

III.2 - Permanent Blackheating Voltage

In order to obtain a maximum life time of the tube, it is recommended to apply continuously a permanent blackheating voltage of 4 V ± 5 %, even during transmitter off-time. During these blackheating periods cooling is not required ; nevertheless, as the allowed maximum temperature must never be exceeded, the water circuit of the Hypervapotron system must not be blocked to allow for free circulation of the water.

III.3 - Operating Heater Voltage

The operating heater voltage depends on the specific tube operating conditions; these conditions should be conveyed to Thomson-CSF which will define the voltage value to be used. This value must be observed within a ± 2 % margin.

For designing the power supply, the heating current is approximately 320 A for a 15 V heater voltage. The heating surge current must not be allowed to exceed 640 A peak on the first cycle.

III.4 - Heater Voltage Measurement

The heater voltage has to be measured directly at the entrance of the tube connector by means of a class 1,5 ferromagnetic or thermal voltmeter or by a digital voltmeter indicating true RMS.

III.5 - Application and Shutdown of the Heater Voltage

The number of on/off cycles is a parameter of great importance for the life duration of the tube. You are invited to consult Thomson-CSF if the number of cycles is more than one per day, in order to determine switch-on conditions after a line shut down.

The rise of the heater voltage from blackheating value to operating value, as well as the reverse operation must be conducted very progressively.

Several procedures may be used to apply or switch off the heater voltage. We recommend that the equipment manufacturer consult Thomson-CSF for detailed information.

IV - APPLICATION OF ELECTRODE VOLTAGES

IV.1 - The tube voltages should be applied in the following sequence :

1 - Apply one-half the nominal heating voltage for 90 seconds, then
2 - The nominal heater voltage, progressively ; wait 5 seconds at full operating voltage, then
3 - Control-grid bias voltage,
4 - Anode voltage,
5 - Screen-grid voltage,
6 - RF driving power.

IV.2 - Removal of Voltages

The voltages should be removed in the reverse order from start-up.

IV.3 - First Use

Before being delivered, each Thomson-CSF tube is submitted to a complete series of factory tests to ensure that it operates according to its specifications.

When using the tube for the first time, it is necessary to perform the following tests :

1. Check the continuity of the filament and the absence of short circuits between electrodes.
2. After having removed the ceramic protector, install the tube using a lifting device avoiding shocks.
3. Make sure the cooling water flows in the right direction. Start the water cooling.
4. Apply the "blackheating" voltage for at least 30 minutes.
5. Apply the heater operating voltage following Thomson-CSF special instructions. After 5 minutes, check this voltage at the connector terminals using a true rms voltmeter, class 1,5 (ferromagnetic, thermal or digital).
6. Leave the heater voltage on for at least 30 minutes and then apply the other voltages.
7. Gradually increase the output power level to carrier conditions.
8. Gradually apply modulation.

V - AUTOMATIC PROTECTIONS

V.1 - Anode Protection

Hypervapotron® anode cooling provides a large safety margin for anode dissipation and for short overloads which might occur.

In addition to the general safety instructions for high voltage operation, the tube protection devices must also act on the anode power supply.

These devices include :

- anode cooling interlocks ;
- protection of heating voltage and control-grid voltage ;
- anode, control grid, and screen grid overcurrent devices ;
- other protection devices of the transmitter circuit and for user's safety.

The tube must also be protected by an arc detector and against overloads which could result from possible mismatching.

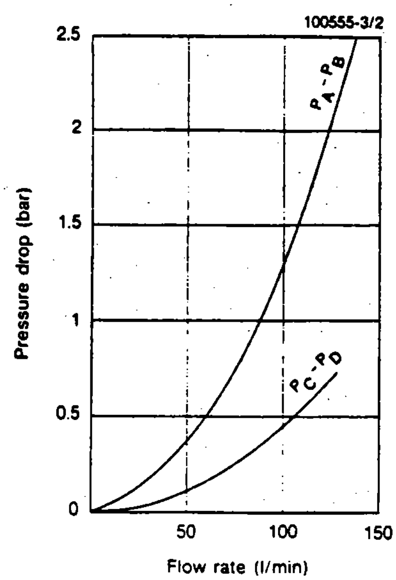
The installation of a "crow-bar" device is recommended to divert the discharge current from the HV power supply filter capacitor in case of arcing. The "crow-bar" device is set by bringing the HV rectifier to full voltage and adjusting the overcurrent relay to its standard sensitivity. A short-circuit is initiated between the anode power supply cables and the cathode through a copper wire. The diameter of this wire is 0.25 mm (0.001 inch) maximum, and its length is about 2 cm per kV. The "crow-bar" must act to shut down the HV before this wire melts.

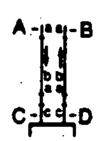
V.2 - Protection Against Overcurrents

The tube should be protected against overcurrents by means of three relays, inserted in series in the control-grid, screen-grid, and anode circuits, respectively. These relays are adjusted to operate when a current equal to 1.5 Imax. is reached, Imax. being the maximum current drawn under normal operating conditions. When one of these relays operates, the RF driving voltage and the screen-grid and anode voltages must be simultaneously cut off.

PRESSURE DROP IN THE WATER JACKET, INCLUDING TUBING AND CONNECTORS

(Figure 1)

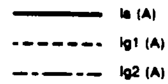


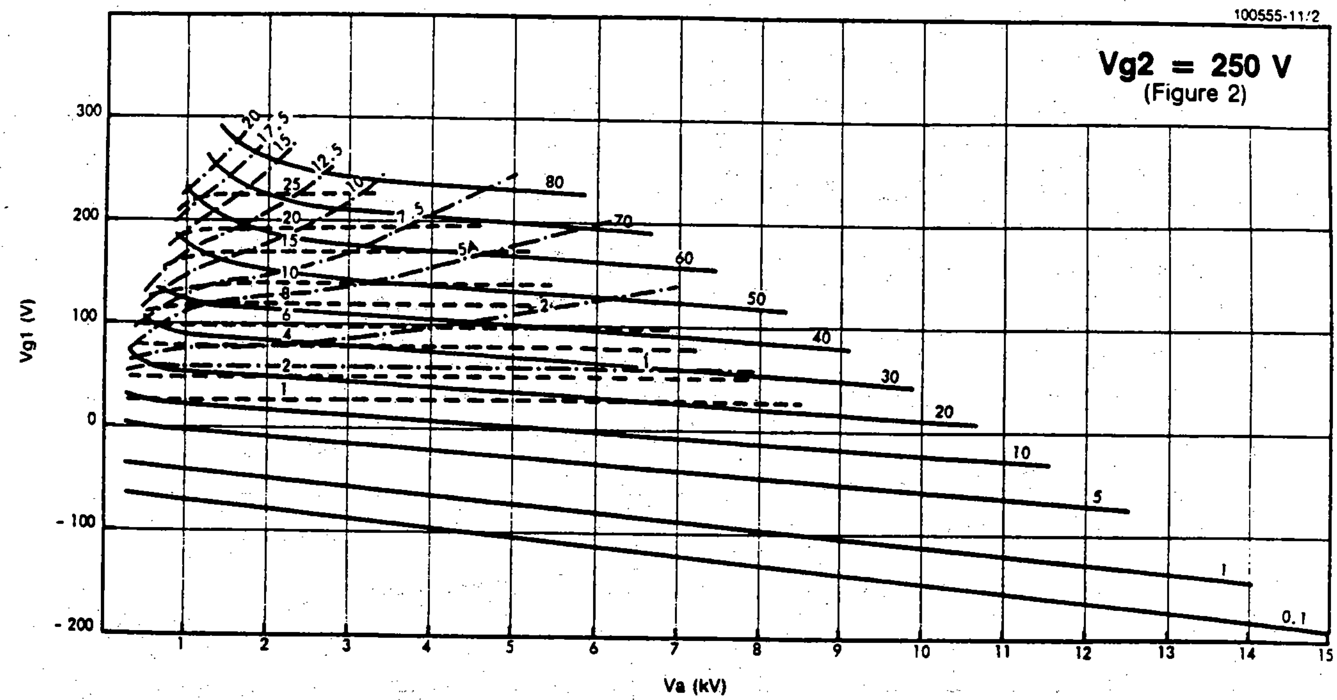


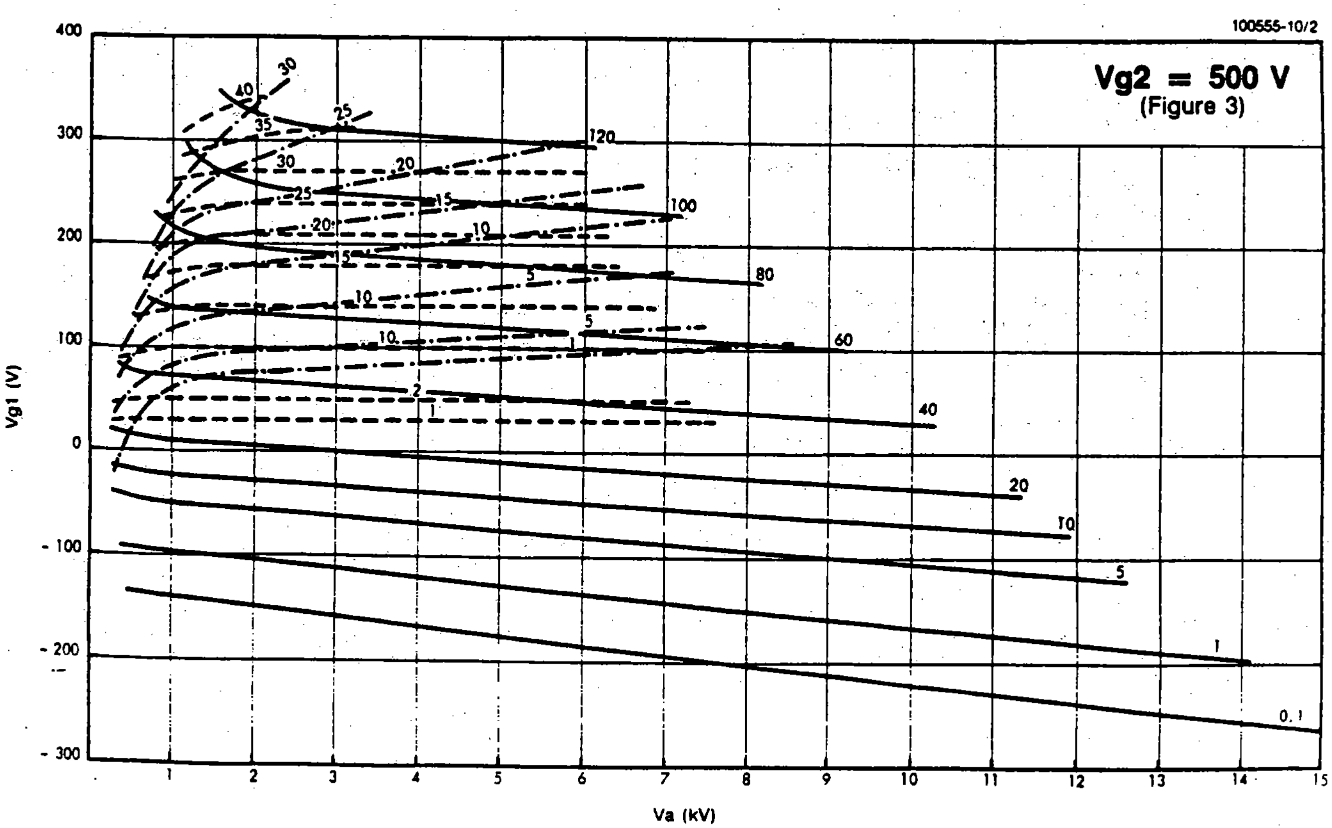
a = TH 17399 antielectrolytic connectors
b = TH 17317 insulating tubing
c = TH 17415B self-obturating fitting

SAFETY WARNING for tubes see DOCUMENT DTE 807

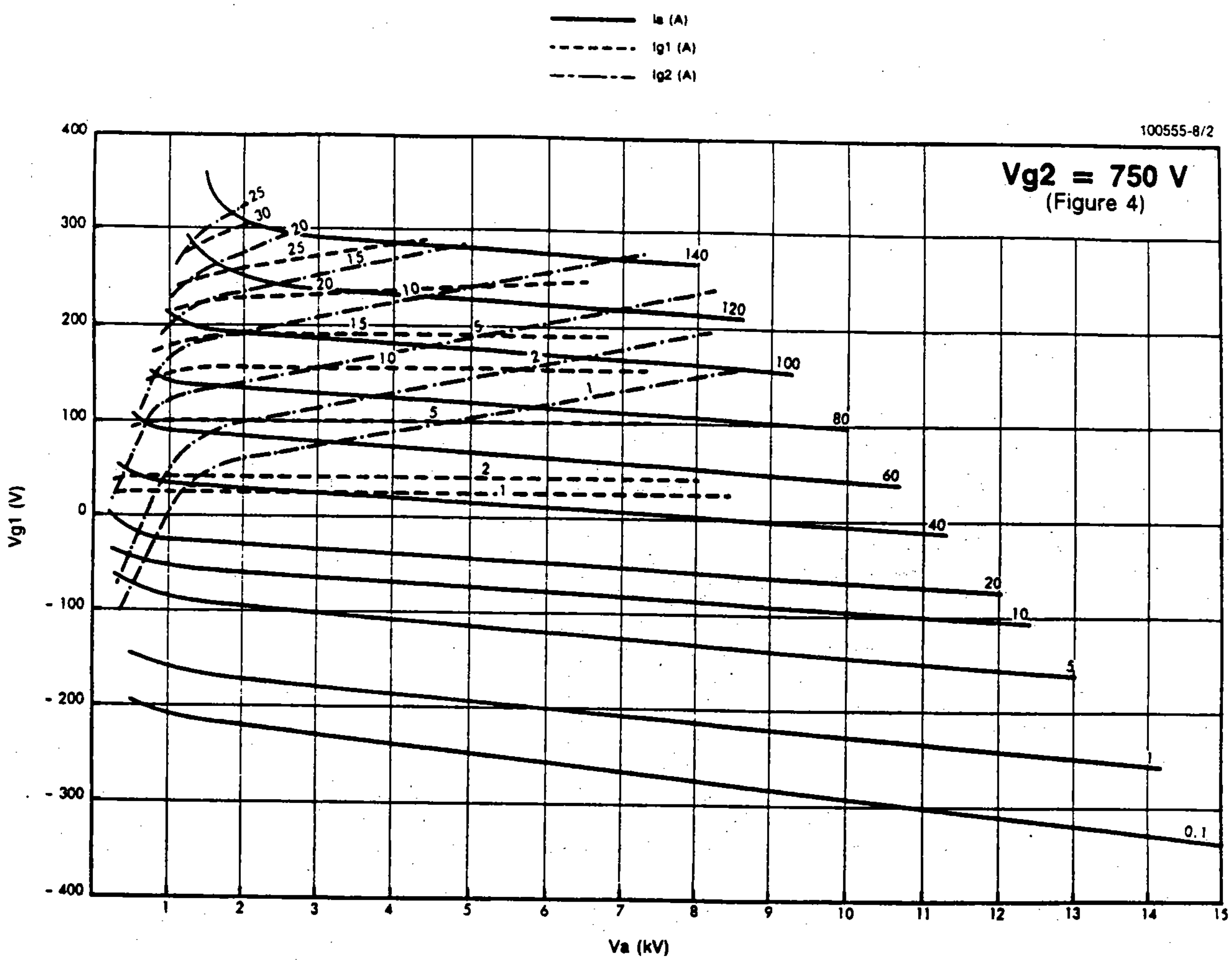
CONSTANT-CURRENT CHARACTERISTICS

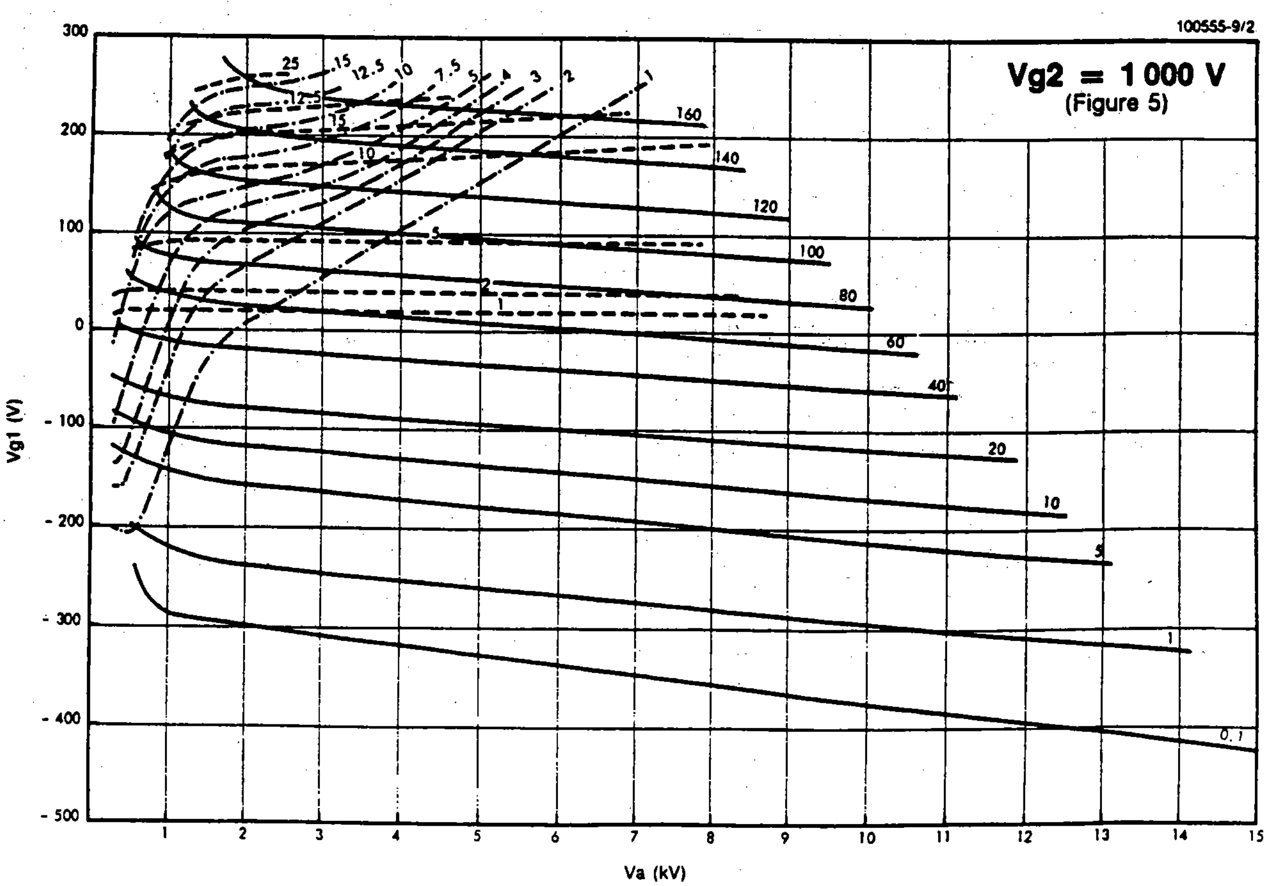




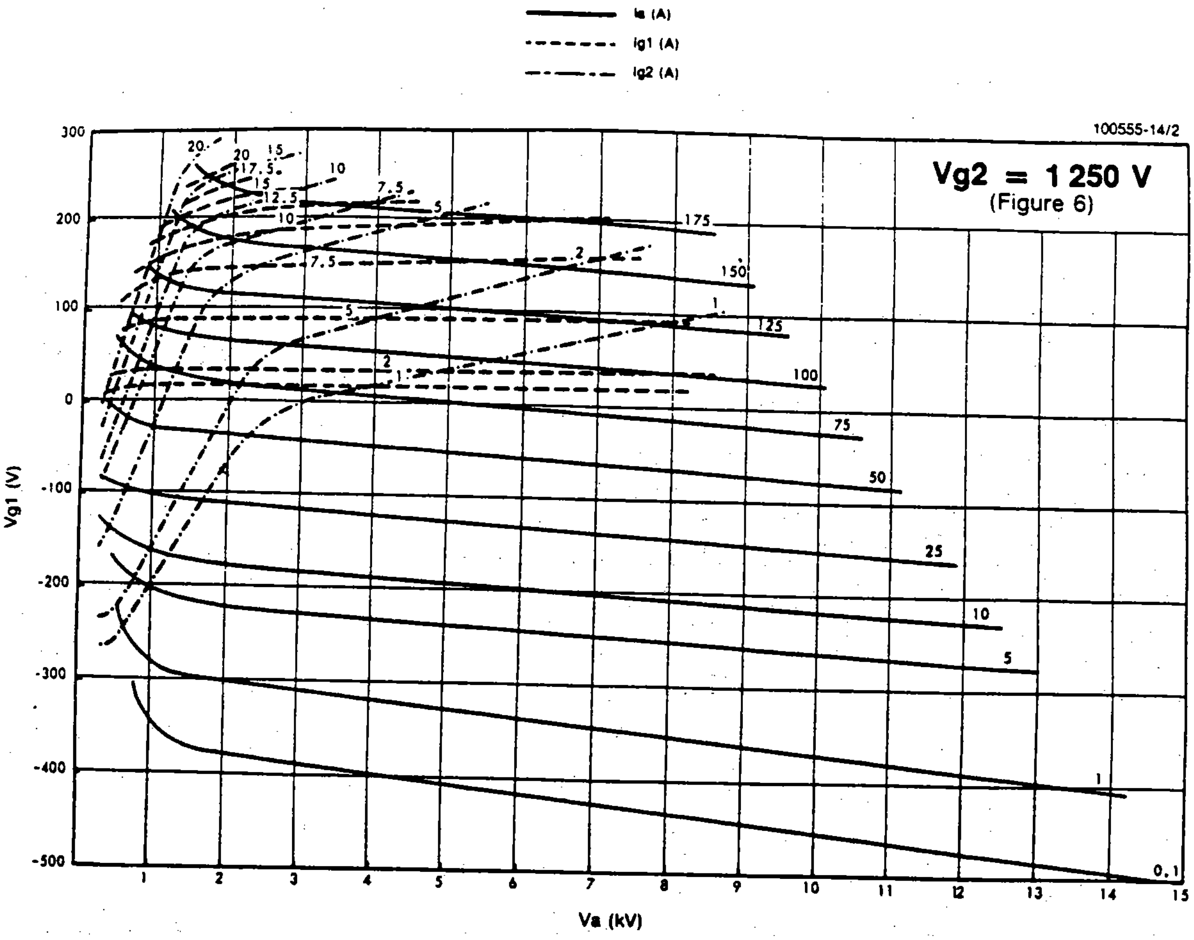


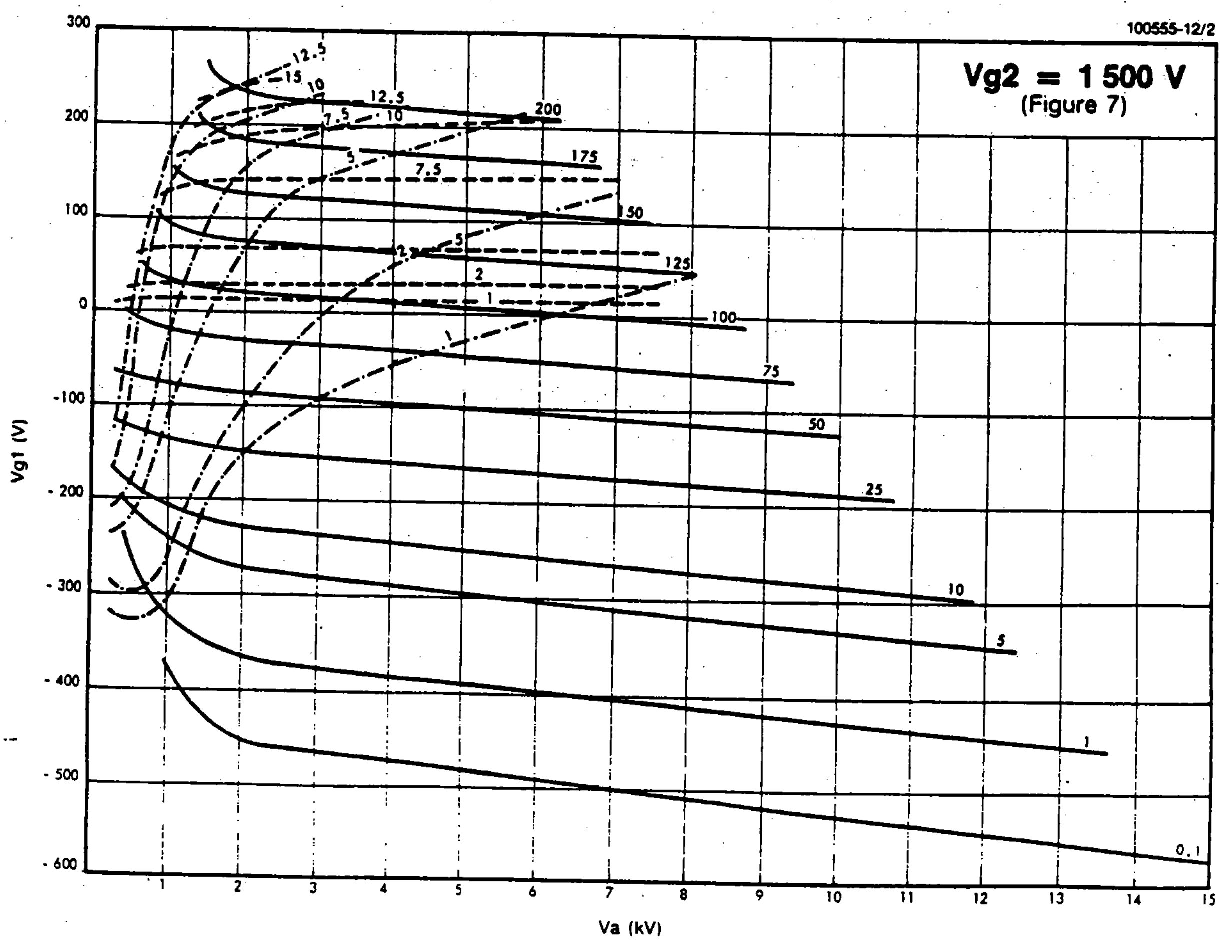
CONSTANT-CURRENT CHARACTERISTICS



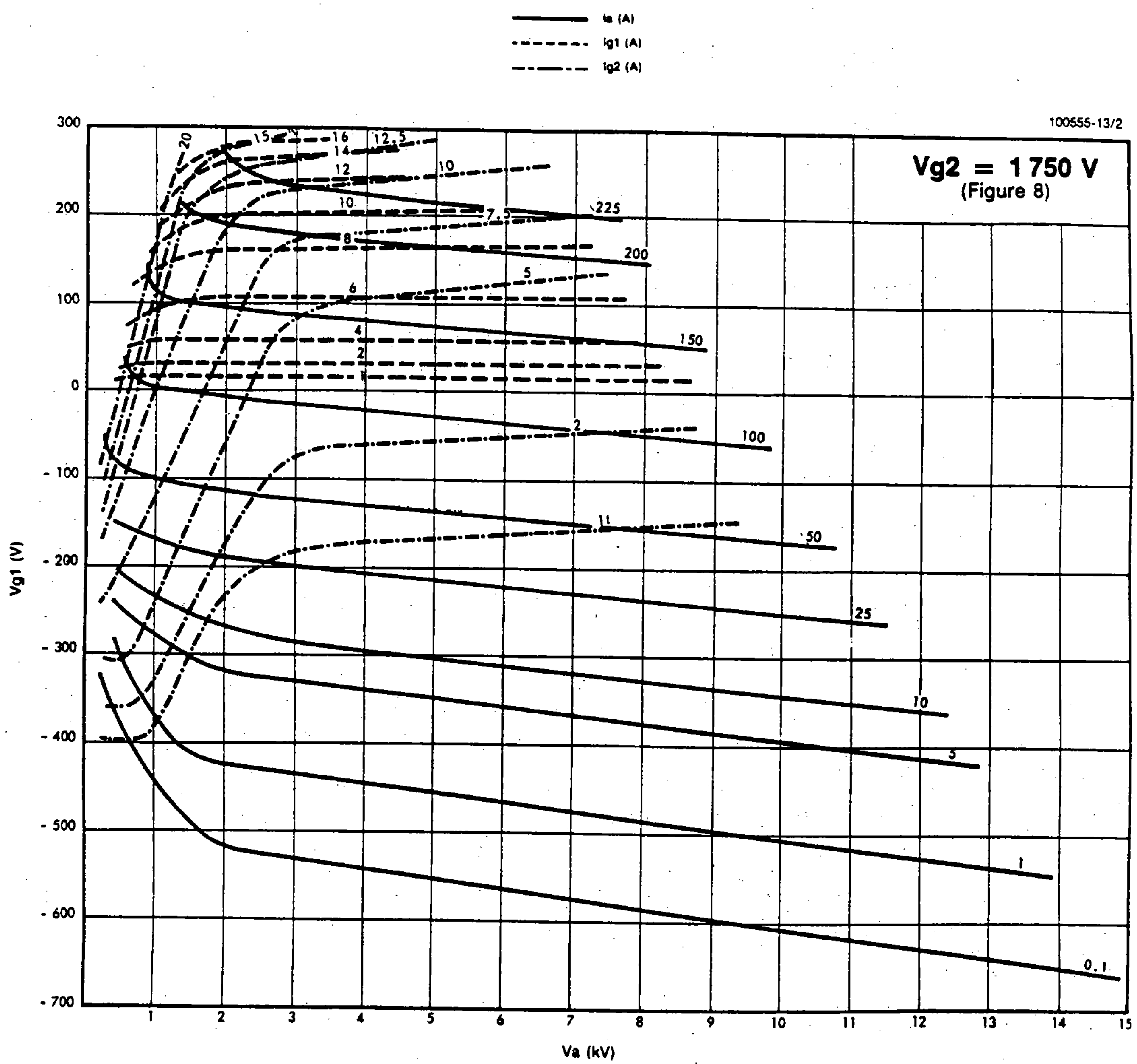


CONSTANT-CURRENT CHARACTERISTICS

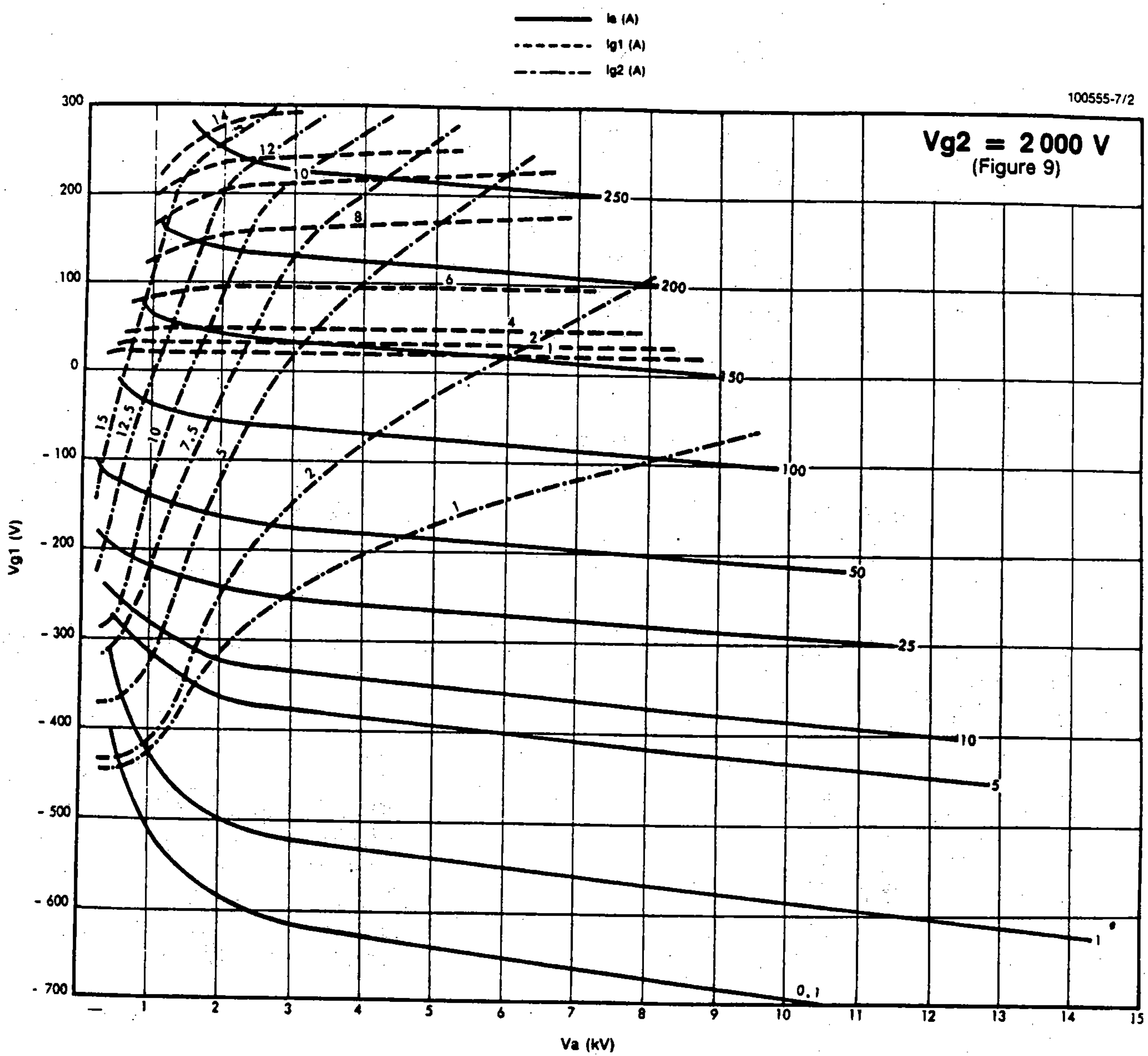




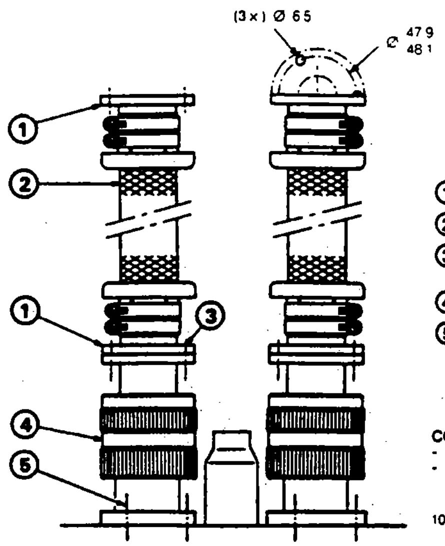
CONSTANT-CURRENT CHARACTERISTICS



CONSTANT-CURRENT CHARACTERISTICS



COOLING-SYSTEM CONNECTIONS
(Figure 10)



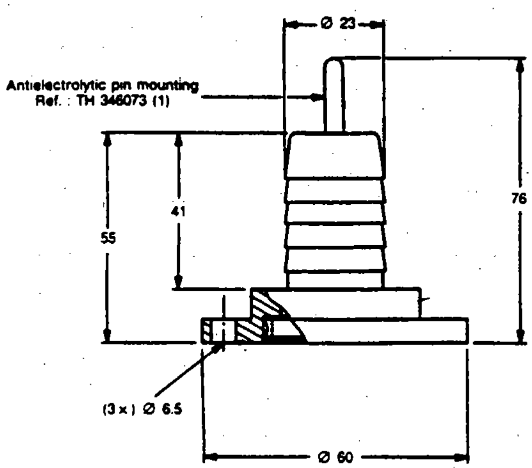
1. Antielectrolytic connector TH 17399
2. Flexible insulating tubing TH 17317
3. HM6 × 20 bolts (× 6)
   Z6U brass washers (× 6)
4. Self-plugging connectors TH 7415B
5. HM6 × 16 screws (× 6)
   Z6U brass washers (× 6)

COOLING :
- Water inlet « IN » (blue mark)
- Water outlet « OUT » (red mark)

100537-7/2

ACCESSORIES
(Figure 11)

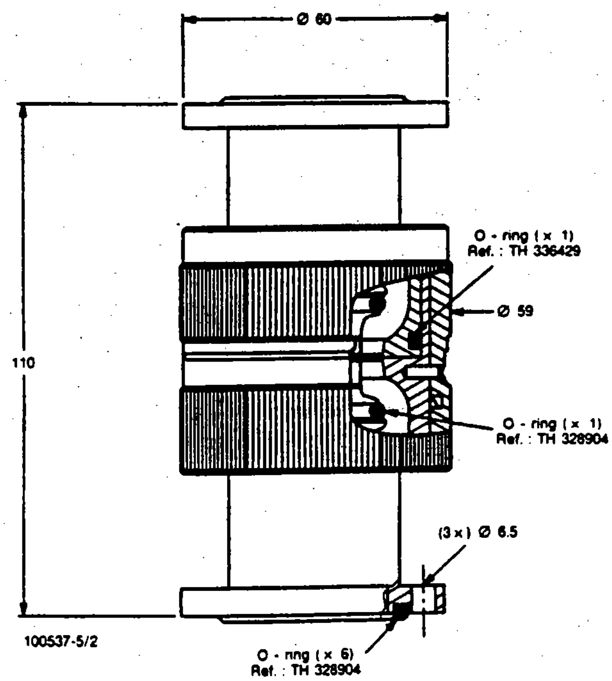
ANTIELECTROLYTIC CONNECTOR
TH 17399



100537-6/2

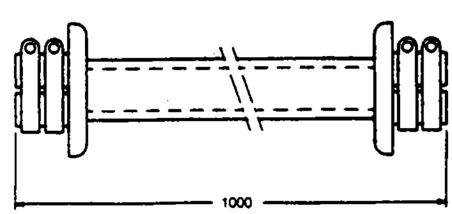
(1) The antielectrolytic plug is screwed to the TH 17397 assembly, thus allowing it to be checked and replaced in case of wear exceedind 15 mm

SELF-PLUGGING CONNECTOR
TH 17415B



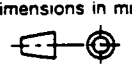
100537-5/2

FLEXIBLE INSULATING TUBING
TH 17317



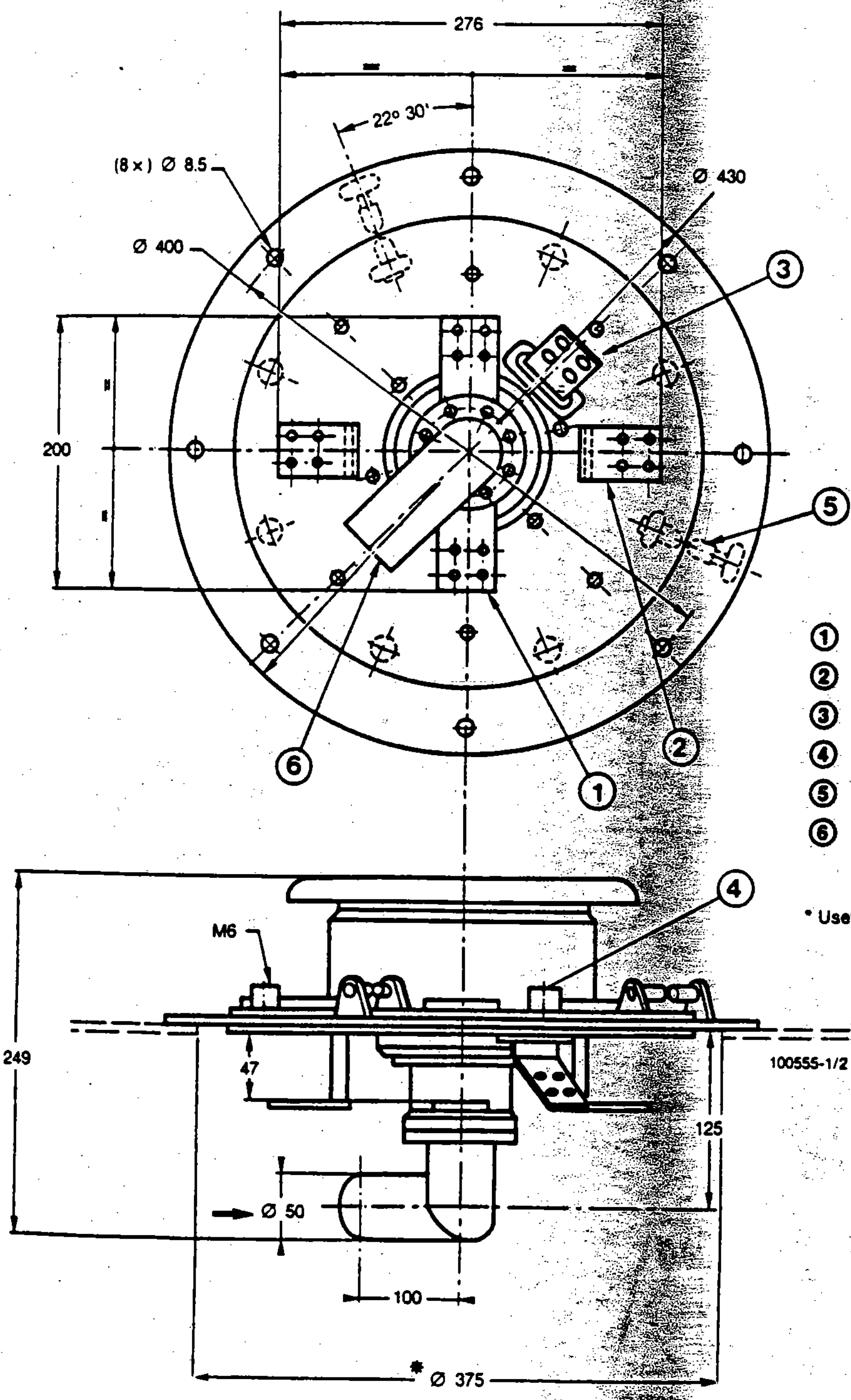
100534-7/2

Dimensions in mm



TH 16110 CONNECTOR

(Figure 12)



① F connections (×2) 180° apart

② FK connections (×2) 180° apart

③ G1 connection

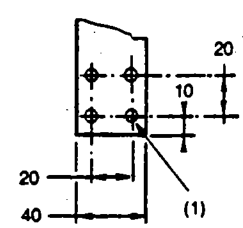
④ G2 connections (×6)

⑤ Spark-gaps K-G2 (×2) 135° apart

⑥ Ventilation :
- Air inlet can be rotated all 45°
- Minimum air flow : 1 m³/min
- Pressure : 12 mbar

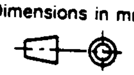
* Useful aperture

Details of connection lugs



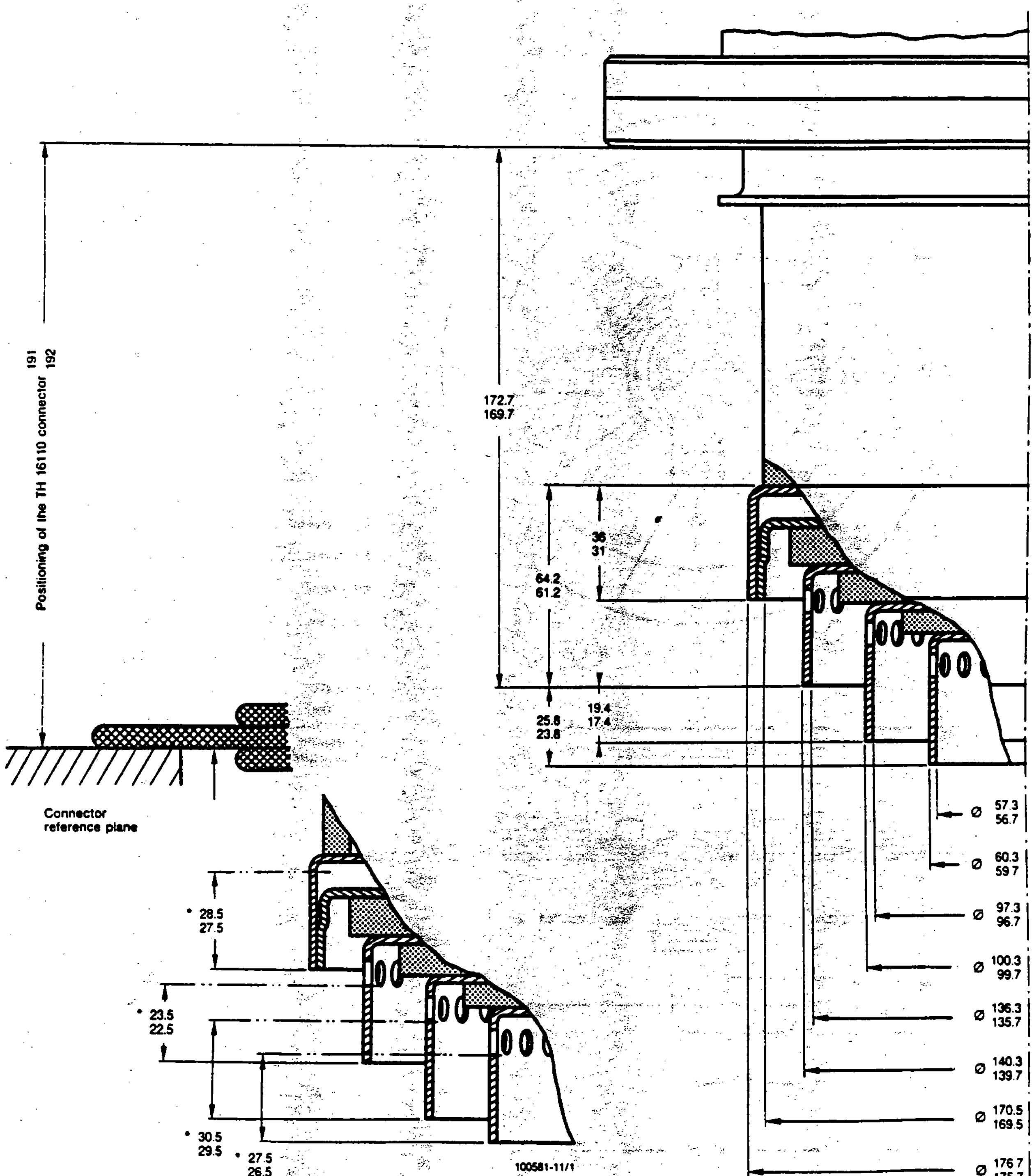
(1) F and FK connections : (4×) Ø 6.5 - Thickness : 6
G1 connection (4×) Ø 6.5 - Thickness : 1.5

Dimensions in mm



DETAILS OF THE ELECTRICAL CONNECTIONS

(Figure 13)

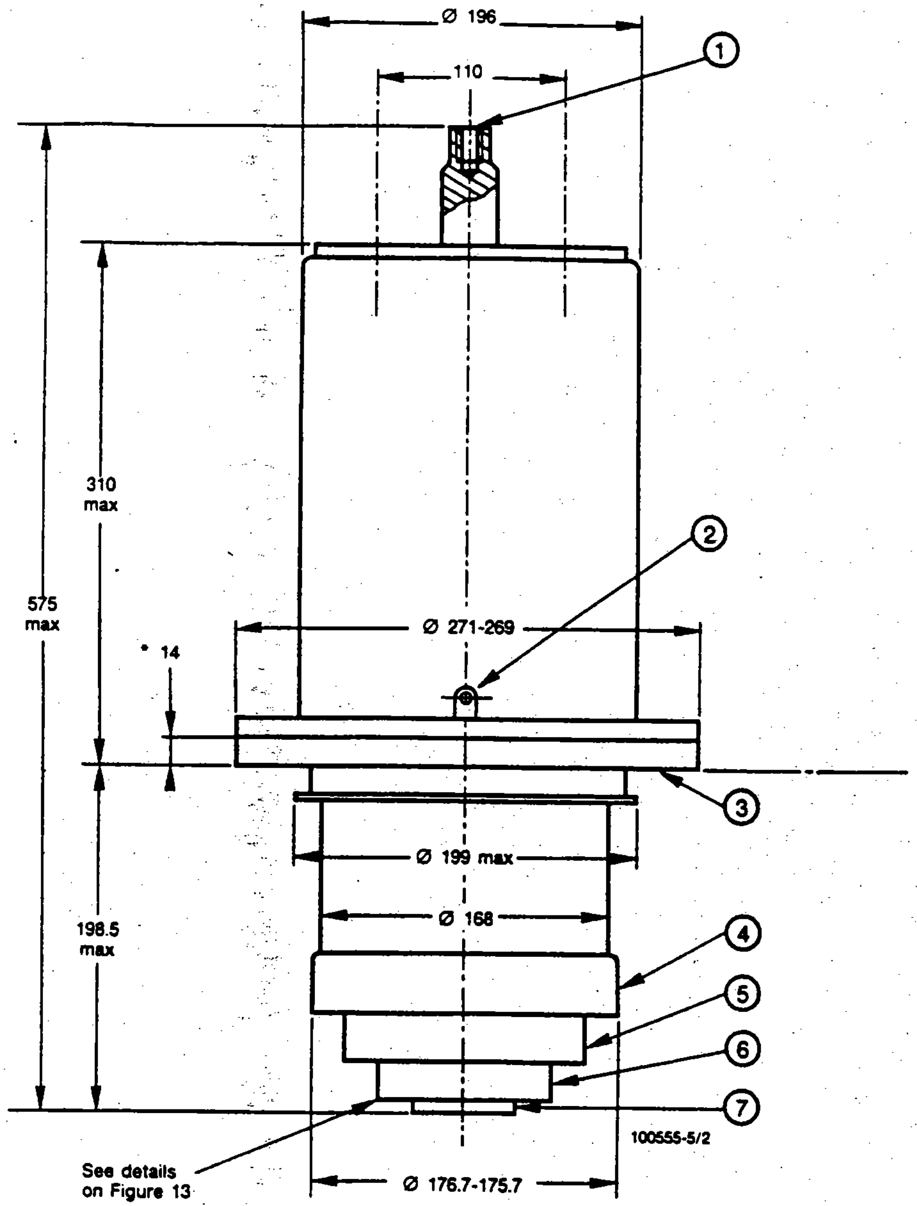


Maximum excentricity : 0.5

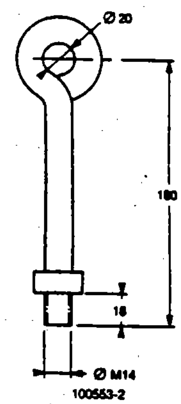
* Contact zones

Dimensions in mm

OUTLINE DRAWING
(Figure 14)



LIFTING DEVICE
TH 14218

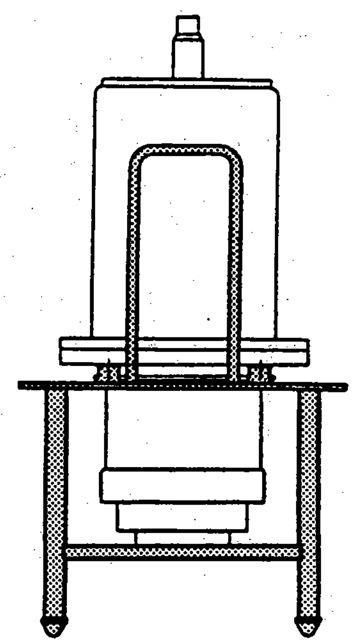


1. M14 hole for fastening the TH 14218 lifting device
2. Water drain for tube remoued from the transmitter
3. Anode
4. Screen grid (g2)
5. Control grid (g1)
6. Filament-cathode
7. Filament

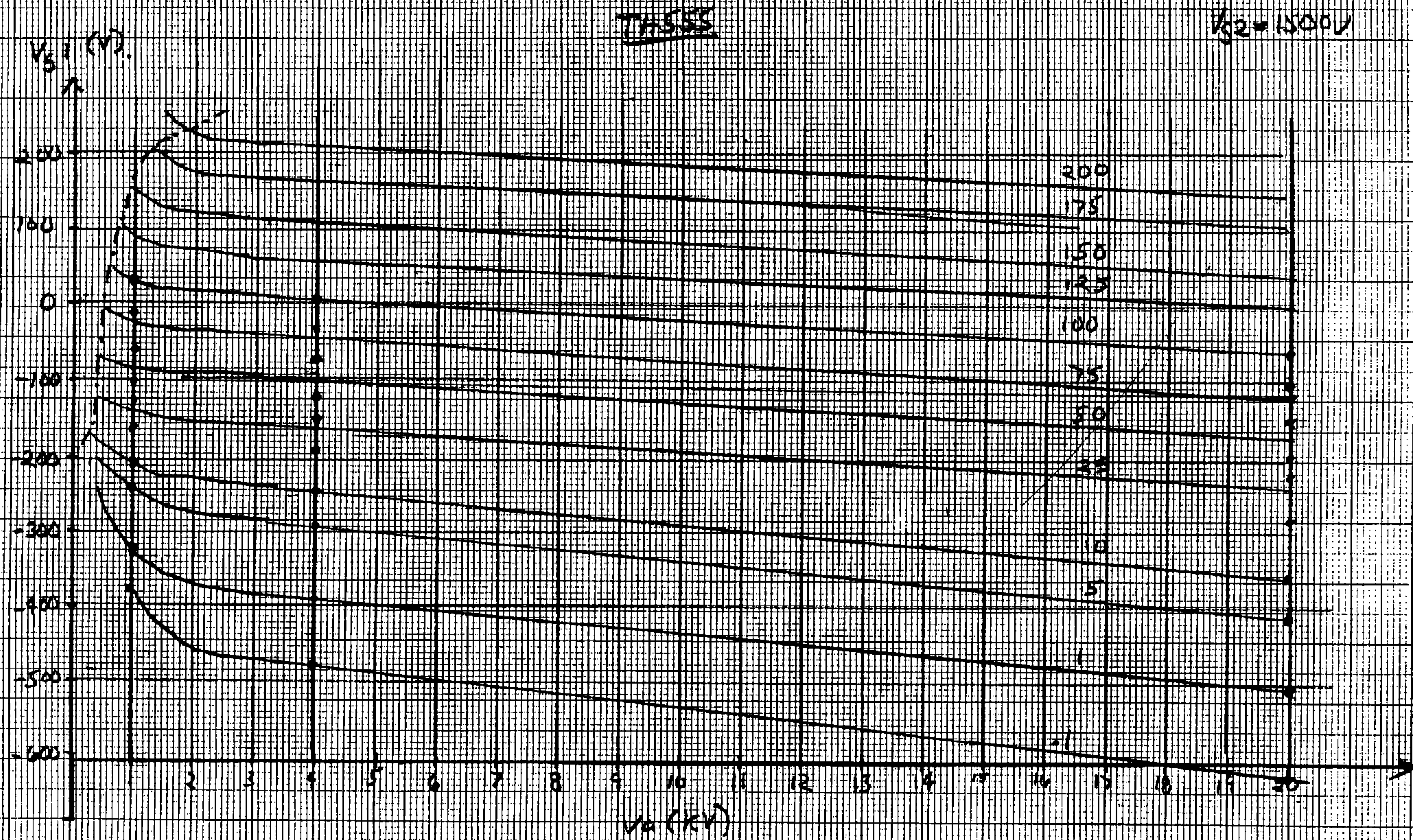
—— · —— Reference plane

* Contact zone

Tube on its shock absorbing support



Dimensions in mm

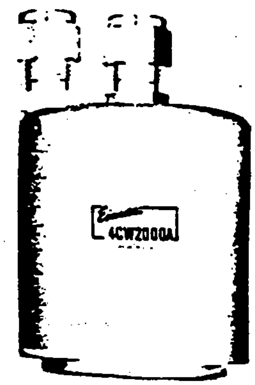

TH555
Vg2 = 1500V
Vg1 (V)
200
100
0
-100
-200
-300
-400
-500
-600
Va (kV)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
200
175
150
125
100
75
50
25
10
5
1
.1

TECHNICAL DATA

8244
4CW2000A

CERAMIC POWER TETRODE

The EIMAC 8244/4CW2000A is a ceramic/metal water cooled radial-beam tetrode with a rated maximum plate dissipation of 2000 watts. It is a low-voltage high current tube designed for Class AB1 rf linear amplifier or audio amplifier applications where its high gain may be used to advantage. It is also recommended for voltage or current regulator service. As a regulator, the maximum dc plate voltage rating is 6000 volts. The 8244/4CW2000A is the water-cooled version of the 8168/4CX1000A.



GENERAL CHARACTERISTICS[1]

ELECTRICAL

Cathode: Oxide-coated Unipotential	
Heater Voltage	6.0 ± 0.3 V
Heater Current, at 6.0 volts	9.0 A
Transconductance (Average):	
$I_b = 1.0$ Adc, $E_{c2} = 325$ Vdc	37,000 μmhos
Amplification Factor (Average):	
Grid to Screen	3.8
Direct Interelectrode Capacitance (grounded cathode)[2]	
Cin	81.5 pF
Cout	11.8 pF
Cgp	0.015 pF
Frequency of Maximum Rating:	
CW	110 MHz

1. Characteristics and operating values are based on performance tests. These figures may change without notice as the result of additional data or product refinement. EIMAC Division of Varian should be consulted before using this information for final equipment design.

2. Capacitance values are for a cold tube as measured in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

MECHANICAL

Maximum Overall Dimensions:	
Length	5.69 in; 144.5 mm
Diameter	2.66 in; 67.6 mm
Net Weight	27 oz; 766 gm
Operating Position	Vertical
Maximum Operating Temperature:	
Ceramic/Metal Seals	250°C
Cooling	Water
Base	Special, breechlock terminal surfaces
Recommended Socket	EIMAC SK-800 Series

(Revised 6-15-71) Printed in U.S.A.

EIMAC division of varian / 301 industrial way / san carlos / california 94070

RADIO FREQUENCY LINEAR AMPLIFIER GRID DRIVEN

Class AB_1 or B (Single Side-Band Suppressed-Carrier Operation)

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	3000	VOLTS
DC SCREEN VOLTAGE	400	VOLTS
DC PLATE CURRENT	1.0	AMPERE
PLATE DISSIPATION	2000	WATTS
SCREEN DISSIPATION	12	WATTS
GRID DISSIPATION	0	WATTS

TYPICAL OPERATION (Frequencies to 30 MHz)
Class AB_1, Grid Driven, Peak Envelope or Modulation Crest Conditions

Plate Voltage	2000	2500	3000	Vdc
Screen Voltage	325	325	325	Vdc
Grid Voltage [1]	-60	-60	-60	Vdc
Zero-Signal Plate Current	250	250	250	mAdc
Single-Tone Plate Current [2]	890	885	875	mAdc
Two-Tone Plate Current [2]	645	650	635	mAdc
Zero-Signal Screen Current [2]	8	6	5	mAdc
Single-Tone Screen Current [2]	35	35	35	mAdc
Two-Tone Screen Current [2]	10	8	8	mAdc
Plate Output Power	930	1300	1630	W

1. Adjust to specified zero-signal dc plate current.
2. Approximate value.

AUDIO FREQUENCY POWER AMPLIFIER OR MODULATOR

Class AB , Grid Driven, Sinusoidal Wave

ABSOLUTE MAXIMUM RATINGS (per tube)

DC PLATE VOLTAGE	3000	VOLTS
DC SCREEN VOLTAGE	400	VOLTS
DC PLATE CURRENT	1.0	AMPERE
PLATE DISSIPATION	2000	WATTS
SCREEN DISSIPATION	12	WATTS
GRID DISSIPATION	0	WATTS

TYPICAL OPERATION (Two Tubes)

Plate Voltage	2000	2500	3000	Vdc
Screen Voltage	325	325	325	Vdc
Grid Voltage [1]	-60	-60	-60	Vdc
Zero-Signal Plate Current	500	500	500	mAdc
Maximum-Signal Plate Current	1.78	1.77	1.75	Adc
Zero-Signal Screen Current [2]	16	12	10	mAdc
Maximum-Signal Screen Current [2]	70	70	70	mAdc
Plate Output Power	1860	2600	3260	W
Load Resistance (Plate to Plate)	2040	2850	3860	Ω

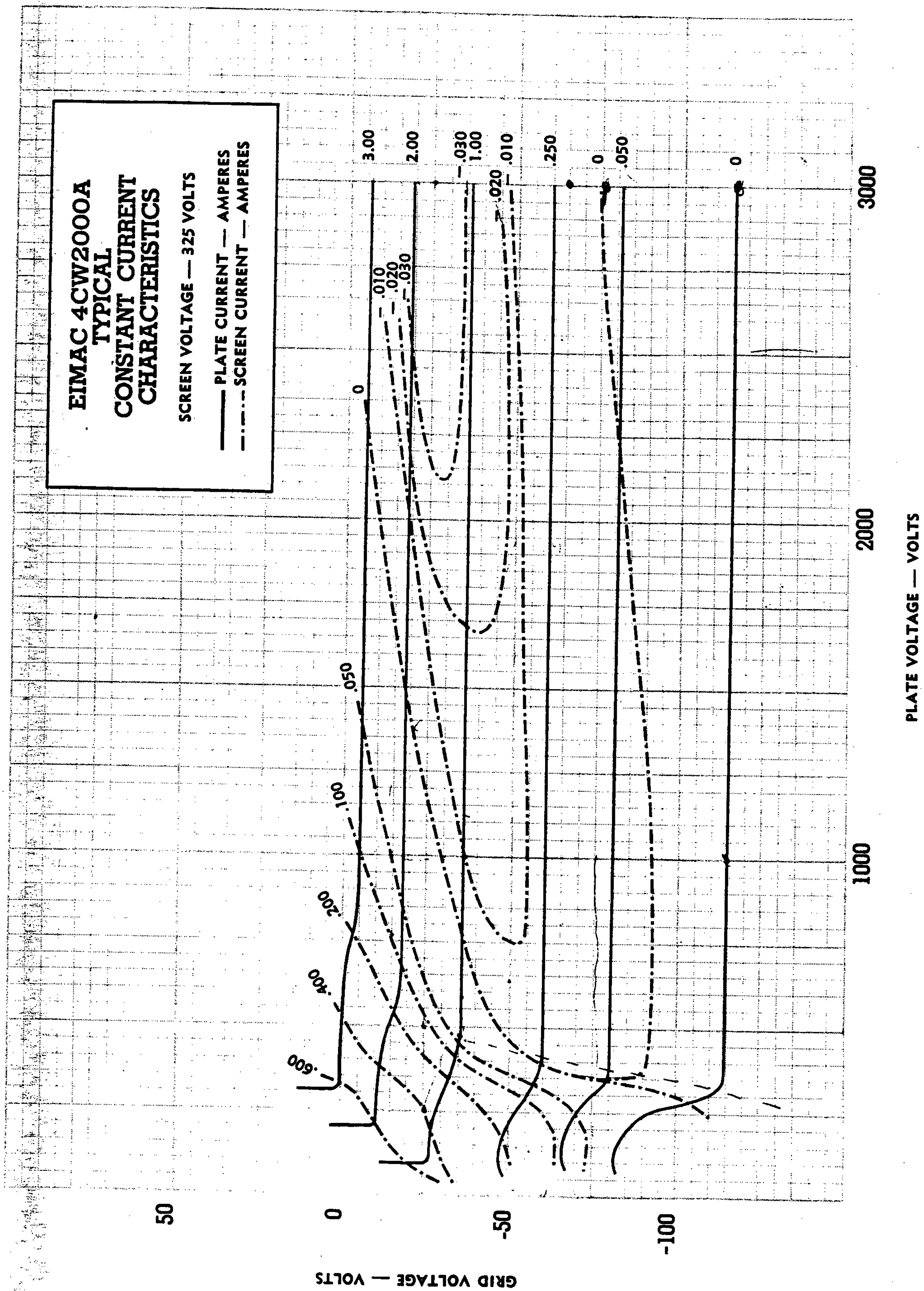
1. Adjust to give stated zero-signal plate current.
2. Approximate value.

NOTE: TYPICAL OPERATION data are obtained from direct measurement or by calculation from published characteristic curves. Adjustment of the rf grid voltage to obtain the specified plate current at the specified bias, screen and plate voltages is assumed. If this procedure is followed, there will be little variation in output power when the tube is changed, even though there may be some variation in grid and screen current. The grid and screen currents which result when the desired plate current is obtained are incidental and vary from tube to tube. These current variations cause no difficulty so long as the circuit maintains the correct voltage in the presence of the variations in current. In the case of Class C Service, if grid bias is obtained principally by means of a grid resistor, the resistor must be adjustable to obtain the required bias voltage when the correct rf grid voltage is applied.

RANGE VALUES FOR EQUIPMENT DESIGN

	Min.	Max.	
Heater: Current at 6.0 volts	8.1	9.9	A
Cathode Warmup Time	3.0	---	Min.
Amplification Factor (g1 to g2)	3.2	4.5	---
Interelectrode Capacitance (grounded cathode connection)[1]			
Cin	75.0	88.0	pF
Cout	10.8	12.8	pF
Cgp	---	0.022	pF

1. Capacitance values are for a cold tube as measured in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

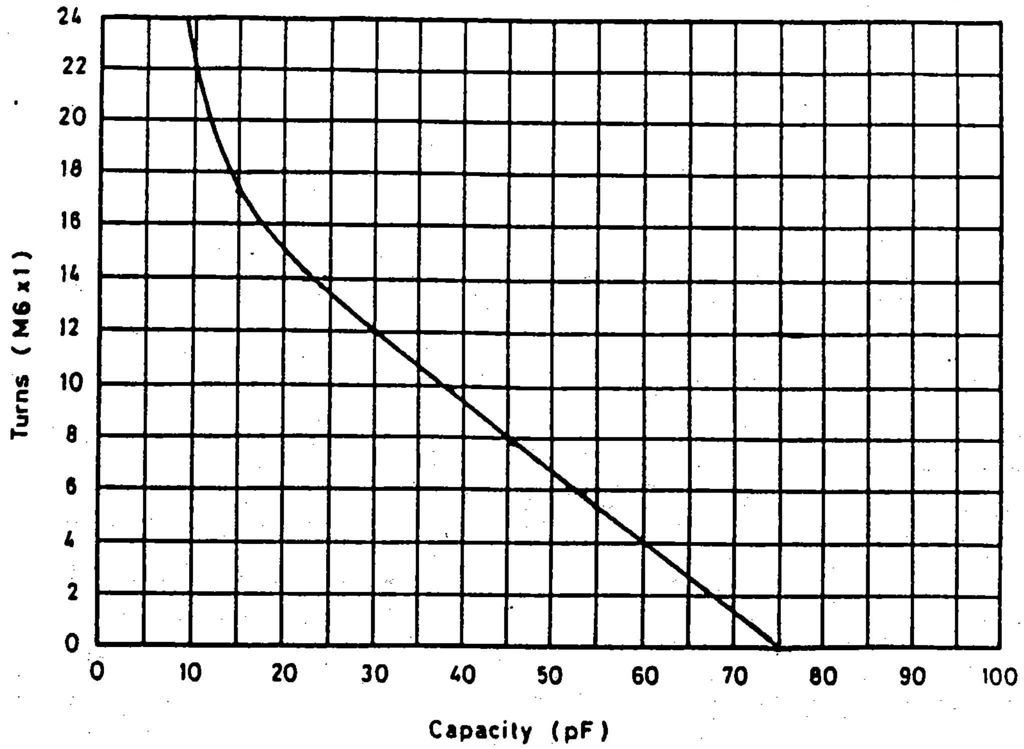

EIMAC 4CW2000A
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE — 325 VOLTS
PLATE CURRENT — AMPERES
SCREEN CURRENT — AMPERES
PLATE VOLTAGE — VOLTS
GRID VOLTAGE — VOLTS
1000
2000
3000
50
0
-50
-100
3.00
2.00
1.00
.250
.050
.030
.020
.010
.600
.400
.200
.100

Appendix E

Vacuum variable capacitor data.

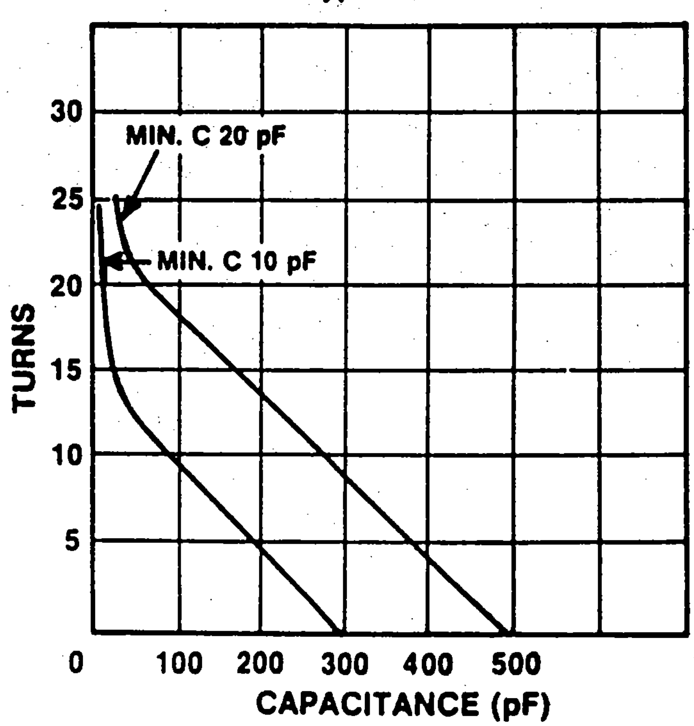
Capacitance vs Turns (typical data)

COMET CV3C75-N900

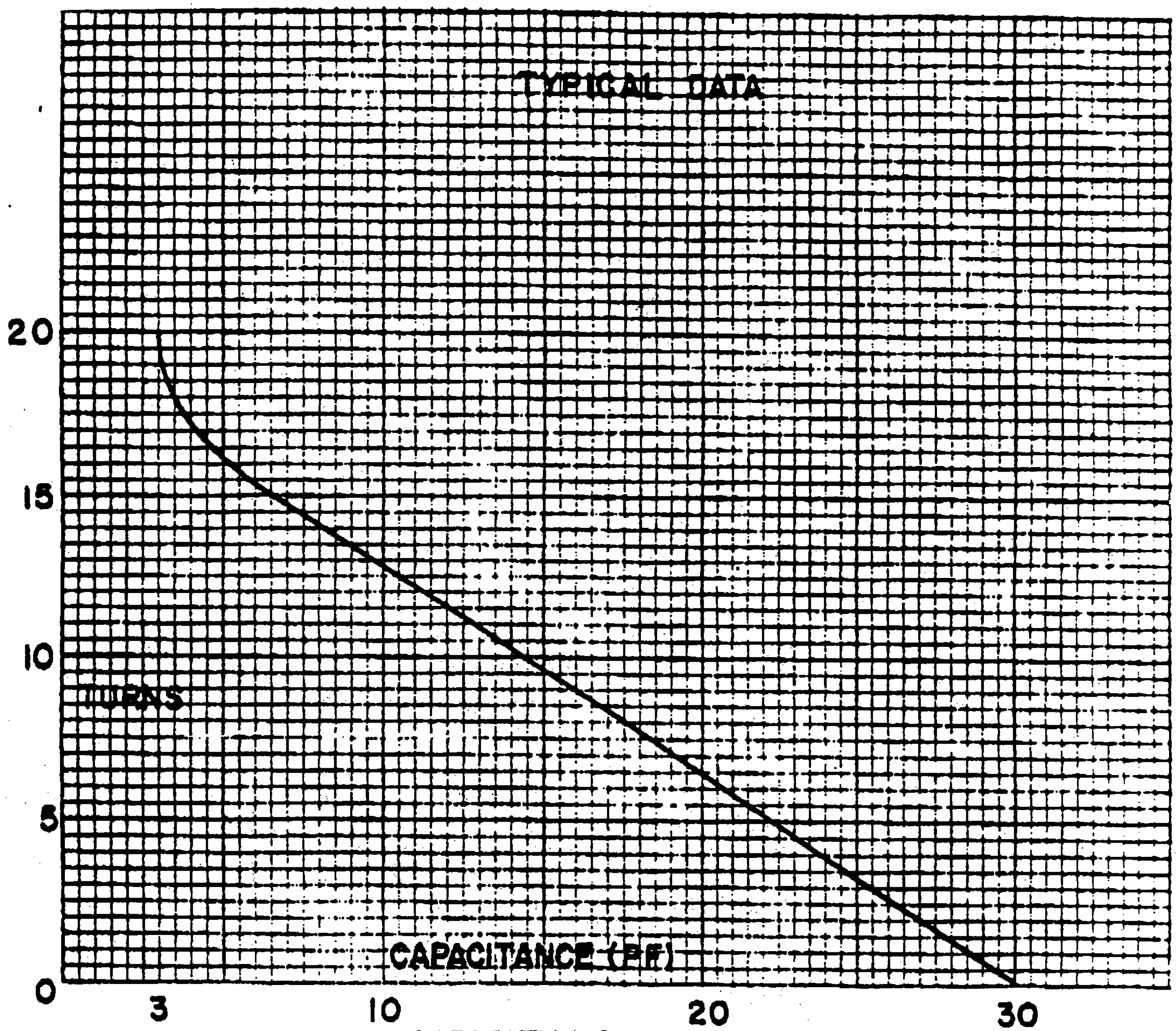


JENNINGS CVDD300 & CVDD500

CAPACITY vs TURNS
Typical Data



JENNINGS CAEC-30-35N785 35KV



CAPACITY VS TURNS

1/4-28 CAP. ADJ. SCREW