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TECHNICAL SPECIFICATION

TETRODE TYPE TH 535

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1. GENERAL CHARACTERISTICS

- Ceramic-metal tetrode with coaxial structure.
- Pyrobloc[®] grids.
- Thoriated tungsten cathode with direct heating.
- Anode cooled by Hypervapotron[®] technique.
- Operating frequency up to 200 MHz.
- Designed for use in either CW or pulsed RF amplifier.
- **High output power :**
 - **CW operation :** 100 kW up to 120 MHz
 - **Pulse operation :** 200 kW up to 200 MHz
- Operating position : vertical, anode up.
- Weight : approx. 14 kg
- Constant current characteristics - see appendices.

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2. SPECIFICATIONS

2.1 ELECTRICAL SPECIFICATIONS

			min	max	unit
Filament current for Vf = 10 V			185	220	A
Interelectrode capacitances电极间电容					
- K - G1.....			150	170	pF
- K - G2.....			7.8	9.2	pF
- K - A.....			0.1	0.15	pF
- G1 - G2.....			185	220	pF
- G1 - A.....			1.1	1.7	pF
- G2 - A.....			28	32	pF
Amplification factor					
VG2 ₁ = 1000/1200 V	Ia = 3 A	Va = 6 kV	6.5	8.5	V/V
Transconductance					
VG2 = 800 V	Ia = 3 A / 5 A	Va = 8 kV	110		mA/V
Control grid voltage					
VG2 = 800 V	Ia = 5 A	Va = 8 kV	- 60	- 85	V
Control grid reverse current					
VG2 = 800 V	Ia = 5 A	Va = 8 kV		1000	μA

2.2 机械性能

. 尺寸 NT 535 see appendix 1
 ND 535 see appendix 2

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3. OPERATING DATA 运行数据

3.1 MAXIMUM RATINGS 最大额定量 ⁽¹⁾

3.1.1 最大电气额定值 Electrical ratings (maximum values)

. Maximum heater ⁽²⁾ surge current	300 A
. Anode dissipation	100 kW
. Screen grid dissipation	1.2 kW
. Control grid dissipation	0.5 kW
. Anode voltage ⁽¹⁾	20 kV
. Screen grid voltage	1500 V
. Control grid voltage	-600 V
. Peak cathode current	110 A

3.1.2 Cooling

. Maximum pressure at water jacket inlet	5 bar
. Maximum temperature of outlet water	80 °C
. Maximum temperature drop in water jacket	40 °C
. Minimum anode water flow for 100 kW dissipated	70 l/min
. Maximum temperature at any point on the tube envelope	200 °C
. Cooling of the electrodes connection	Force air
. Minimum air flow for an air temperature of 25 °C at sea level	2 m ³ /min

3.2 HEATER VOLTAGE

Direct, DC or single phase AC heating - see page 11 -

IF DC the positive wire must be connected to the cathode

(1) Maximum ratings are absolute limiting values ; no one value may be exceeded, even under transient conditions. Do not operate at more than one limiting value at the same time. Equipment should be designed to protect the tube against any excess values.

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3.3 EXAMPLES OF APPLICATIONS

RF amplifier operation

(All voltages referenced to cathode)

a/ CW operation (Cavity TH18535) : example of application

Operating frequency	55	MHz
Anode voltage	10	kV
Screen grid voltage	800	V
Control grid voltage	-110	V
Anode current	16.5	A
Screen grid current	0.3	A
Control grid current	1.5	A
Anode dissipation	65	kW
Output power	100	kW
. Input power	3.2	kW

b/ CW operation (Cavity TH18546) : example of application

Operating frequency	106	MHz
Anode voltage	13.5	kV
Screen grid voltage	1200	V
Control grid voltage	-200	V
Anode current	10	A
Screen grid current	0.5	A
Control grid current	0.2	A
Gain	16	dB
Output power*	100	kW
Input power	2.5	kW

* At the cavity output

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c/ Long Pulse (Cavity TH18535) :example of application

Operating frequency	120	MHz
Anode voltage	9	kV
Screen grid voltage	800	V
Control grid voltage	-110	V
Anode current *	14.5	A
Screen grid current*	0.3	A
Control grid current*	1.1	A
Anode dissipation*	80	kW
Output power	80	kW
Pulse duration	≤30	s
Duty factor	12.5	%.
VSWR	≤ 1.5	

* During Pulse

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4. OPERATING INSTRUCTIONS

4.1 RECEIVING, HANDLING AND STORAGE

4.1.1 Receipt of the tube

- On receipt of a tube, without removing it from its packaging, check for any damage which may have occurred during transportation :
 - inspect the inside and outside of the package (see note),
 - check the tilt detector (see note).
- - Remove the tube using the lifting device (TH14218),
- Check that the tube bears no traces of impact (see note),
- Check filament continuity and absence of short circuits between the electrodes using an ohmmeter (see note).

Note : In case of damage

Refer to the instructions on the back of the delivery note in the « Documents » envelope stapled to the package. Claims should be made to the last shipper within the requisite period.

4.1.2 Handling

Move the tube **avoiding all impacts**

- 1/ to the storage place
- 2/ to the operating position

Install the tube in the system in accordance with the instructions in paragraph 4.4.3 « First use ».

IMPORTANT

Shocks and vibrations can damaged the tube. Avoid any unnecessary handling.

4.1.3 Storage

The tube must be stored in dry, dust-free premises (relative humidity between 40 and 70%).
All tubes must be stored in the vertical position.

Tubes are delivered with removable ceramic protectors which must remain in place during storage.
Tube ceramics must be kept clean. Ceramics which have been inadvertently soiled may be cleaned using alcohol and, if necessary, with alumina powder.

Do not use an abrasive or metal pad to clean tube ceramics.

See Document TED 807 for risks associated with tubes

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4.2 TUBE COOLING

4.2.1 Hypervapotron anode cooling

Like all Hypervapotron-cooled tubes, the TH 535 is delivered with the water jacket in place, and with the water inlet and outlet marked (« IN » in blue for the inlet, and « OUT » in red for the outlet).

The incoming water supply must always be connected to the cooler inlet, and outgoing water must always be evacuated via the outlet.

For connections, see appendix.

The cooling water must be demineralized. **Its resistivity at 20°C must be maintained at 500 kWcm or higher** by means of a regeneration circuit.

A protective device connected to the tube's protective system must be provided to shut down the installation if the resistivity of the water falls below 100 kWcm.

The cooling **water** must be carefully **filtered** to remove any solid particles which might obstruct the water flow, leading to a drop in cooling efficiency and create a **tube failure**.

Protective devices, connected to the tube's protective system, must be provided for :

- inlet water pressure,
- outlet water temperature/flowrate,
- water resistivity.

4.2.2. Cooling of electrode terminals and ceramics

In addition to cooling of the tube anode, the tube ceramics and electrode rings must also be cooled.

The electrode rings and ceramics are cooled by filtered forced air, which must be carefully channeled to ensure effective cooling of seals and rings.

The temperature at any point on the tube **envelope** (rings, ceramics and ceramic-metal seals) **must not exceed 200°C**. This temperature must be checked during equipment installation using temperature-sensitive paint.

A protective device for inlet air pressure and flowrate must be connected to the tube's protective system.

IMPORTANT

Cooling of the anode and the electrode rings must be switched on before, or at the same time as, application of electrode voltages, and must be maintained for at least fifteen minutes after all voltages are removed to allow for tube cool-down.

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4.3 HEATING

DC or single-phase AC heating

4.3.1. Inspection before installation

Before putting a tube into service, use an ohmmeter to check filament continuity and the absence of short-circuits between the electrodes.

4.3.2. Operating heater voltage

The heater voltage is not a generalized characteristic, but must be defined according to the specific tube operating conditions. These conditions must be communicated THALES ELECTRON DEVICES to enable them to define the operating heater voltage value, and pass it on to the user. This value must be adjusted to within $\pm 2\%$ or better.

However, for power supply design, the heater current value will be approximately 200 A for a heater voltage of 10 V.

The heater surge current must never exceed **300 A peak**.

4.3.3. Measuring heater voltage

Check the heater voltage at the connector terminals using a class 1.5 (or better) ferromagnetic, thermal or digital voltmeter indicating the true RMS value.

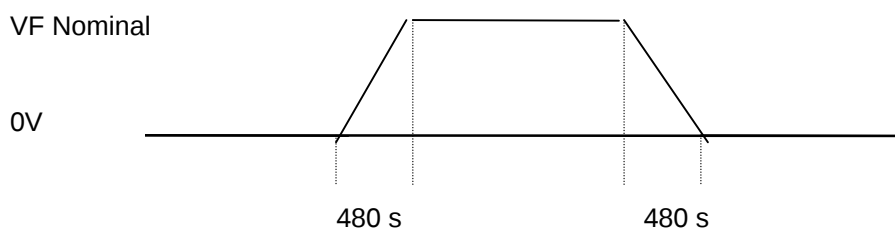
4.3.4. Application and removal of heater voltage

The number of « on/off » cycles between the permanent blackheating voltage and the heater voltage is a key parameter in tube life expectancy. More than one cycle per day is not recommended.

Please contact THALES ELECTRON DEVICES if the number of cycles is more than one per day, and to determine switch-on conditions following a mains shutdown.

Heater voltage must be gradually increased or decreased between the permanent blackheating and the operating heater voltage.

Several procedures may be used to apply or switch off the heater voltage. (see example of usual filament application and shut-down below) We recommend that the equipment manufacturer consult THALES ELECTRON DEVICES.



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4.4 VOLTAGE APPLICATION

4.4.1 Electrode voltage and drive power application sequence

Voltage should be applied in the following order :

- 1 - operating heater voltage, then wait 1 min. at full operating voltage (refer to the heating procedure for this tube),
- 2 - control grid voltage,
- 3 - anode voltage,
- 4 - screen grid voltage,
- 5 - drive power.

This sequence is compulsory

4.4.2 Electrode voltage and drive power removal sequence

Voltages and drive power should be removed in reverse order from voltage application, § 4.4.1.

4.4.3. First use of a tube

When using the tube for the first time, the following operations should be performed :

- ① Check filament continuity and the absence of short circuits between the electrodes.
- ② After removing the ceramic protector, install the tube using the lifting device, avoiding impacts.
- ③ Connect the water cooling circuit. Make sure the cooling water flow direction is correct.
- ④ Start water circulation. Leave the water circulate until the air is removed from the water circuit. Verify for no leakage.
- ⑤ When the water circuits are full the water in the anode being able to circulate freely. Apply the operating heater voltage
- ⑥ After 5 minutes, check the heater voltage at the cavity connector terminals using a class 1.5 ferromagnetic, thermal or digital voltmeter indicating the true RMS value..
- ⑦ Leave the filament on for at least 30 minutes, and then apply the other voltages

4.5 PROTECTIVE DEVICES

The tube must be protected against any overcurrents, overvoltages and overloads which may occur during operation.

On any fault RF drive power must be switched off in less than 100 μ s.

If one of the protective devices is activated, the RF drive power, the screen grid voltage, the anode voltage must be simultaneously switched off.

The protective and safety devices must be set when the equipment is installed and must be checked periodically (once a year minimum) and before installation of a tube.

4.5.1 Anode protection

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

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These devices include :

- low anode cooling water protective device,
- devices in case of lack of heater voltage and/or control grid voltage,
- anode, control grid and screen grid overcurrent devices,
- other protective devices for the transmitter circuit and user safety,
- devices in case of excessive VSWR.

A fast-acting anode protective device, such as a crowbar, must be provided, and checked by short-circuiting the anode rectifier.

To do this, the rectifier is set to nominal operating voltage. A short-circuit is then initiated between the anode and cathode power supply conductors via a copper wire 30/100 mm in diameter and approximately 2 cm/kV long. Source cut-off must be fast enough to avoid melting the copper wire.

4.5.2 Overcurrent protection

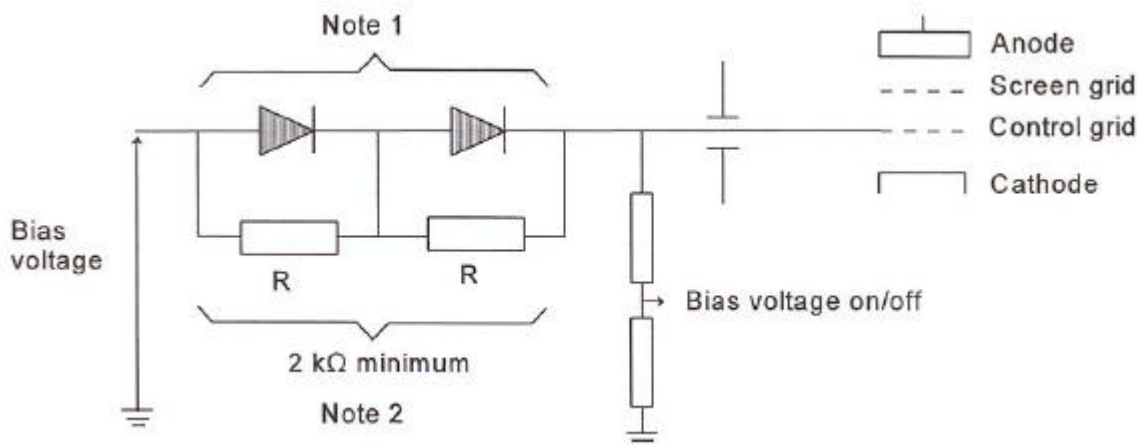
The control grid, screen grid and anode must be protected against overcurrents by means of fast-acting protective devices with a response time of < 20 msec.

These devices must be set to activate when a current equal to 1,5 times the normal maximum operating current is reached.

An additional protective device operated by negative (reverse) control grid current detection is also necessary. The negative current must be limited to 0.5 A.

In case of reverse grid current detected, the control grid, rectifier must be switched off in less than 20 ms and the RF drive power in less than 100 μ s :

To limit the reverse grid current, we recommend the following device :



Note ① : Direct grid current goes through the diodes (they must be calculated for 5000 V reverse voltage).

Note ② : Reverse grid current will be limited to 0.5 Amp maximum by the resistors R in case of KG1 or G1G2 short-circuit.

Test procedure for the control grid reverse current protective device

To do this, the rectifier is set to the nominal operating voltage. A short-circuit is then initiated between the control grid and ground via a 0.5 A fast fuse.

It will be checked that the fuse is not opened.

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4.5.3 Overvoltages protective devices

Spark-gaps or varistors must be installed between :

- control grid and ground set at 2.0 kV
- screen grid and ground set at 2.5 kV

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5. ACCESSORIES - Refer to appendices -

- . Self obturating connector TH 17415B
- . Antielectrolytic connector TH 17399
- . Flexible insulating pipe TH 17317
- . Antielectrolytic connector TH 17382
- . Lifting device TH 14218
- .Socket (grounded grids)TH 16118G (Up to 26 MHz)
- .Socket (grounded cathode) TH16118K (Up to 26 MHz)

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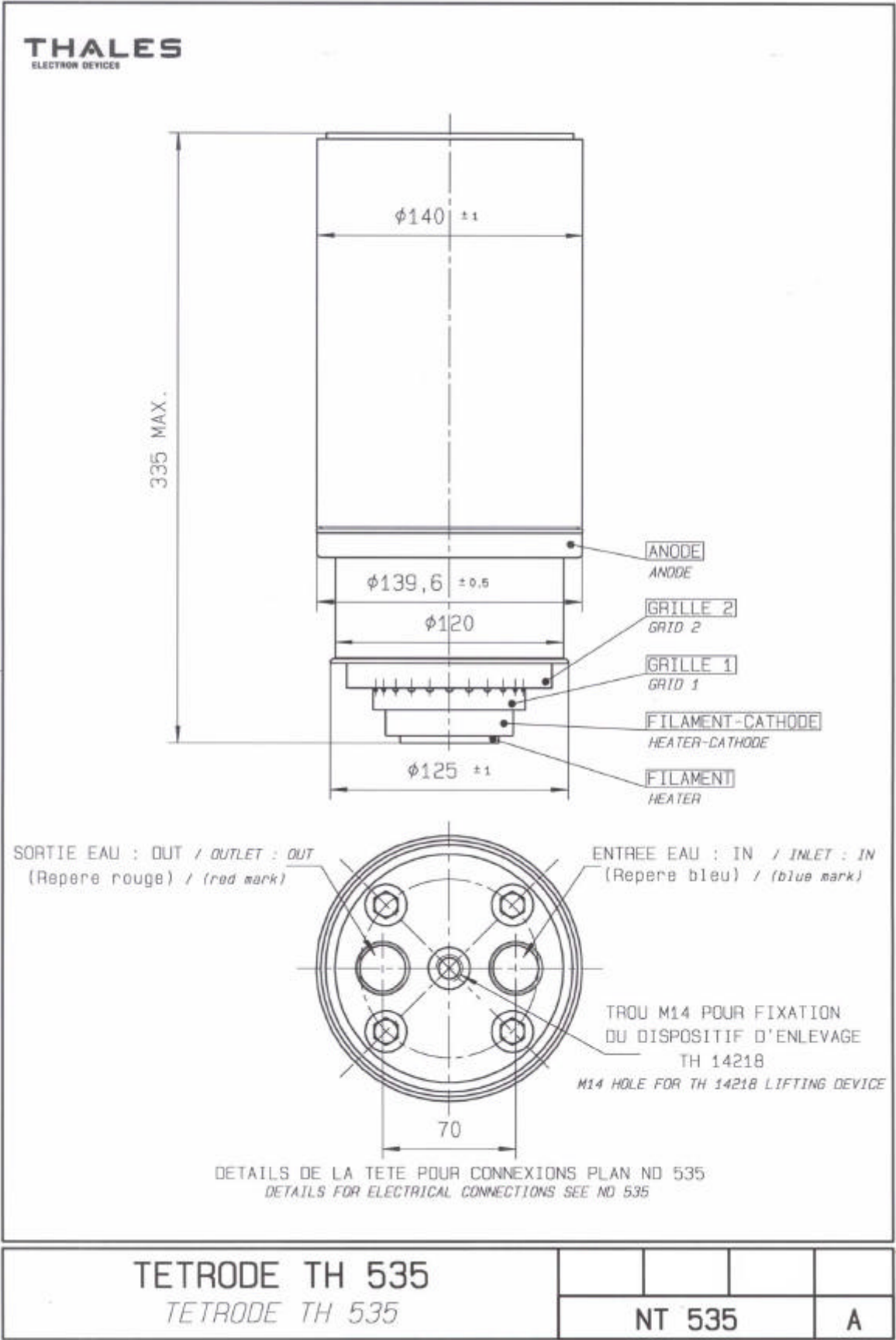
*** LIST OF APPENDICES ***

APPENDIX 1	:	OUTLINE DRAWING NT 535
APPENDIX 2	:	DETAILS FOR ELECTRICAL CONNECTIONS ND 535
APPENDIX 3	:	CONSTANT CURRENT CHARACTERISTICS
APPENDIX 4	:	COOLING CIRCUIT CONNECTIONS NB 535
APPENDIX 5	:	LIFTING DEVICE TH 14218
APPENDIX 6	:	SOCKET TH16118K and TH16118G

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EXCENTRICITE MAX.: 0,3 / MAX. EXCENTRICITY : 0.3

* ZONES POUR CONTACTS / * CONTACT ZONES

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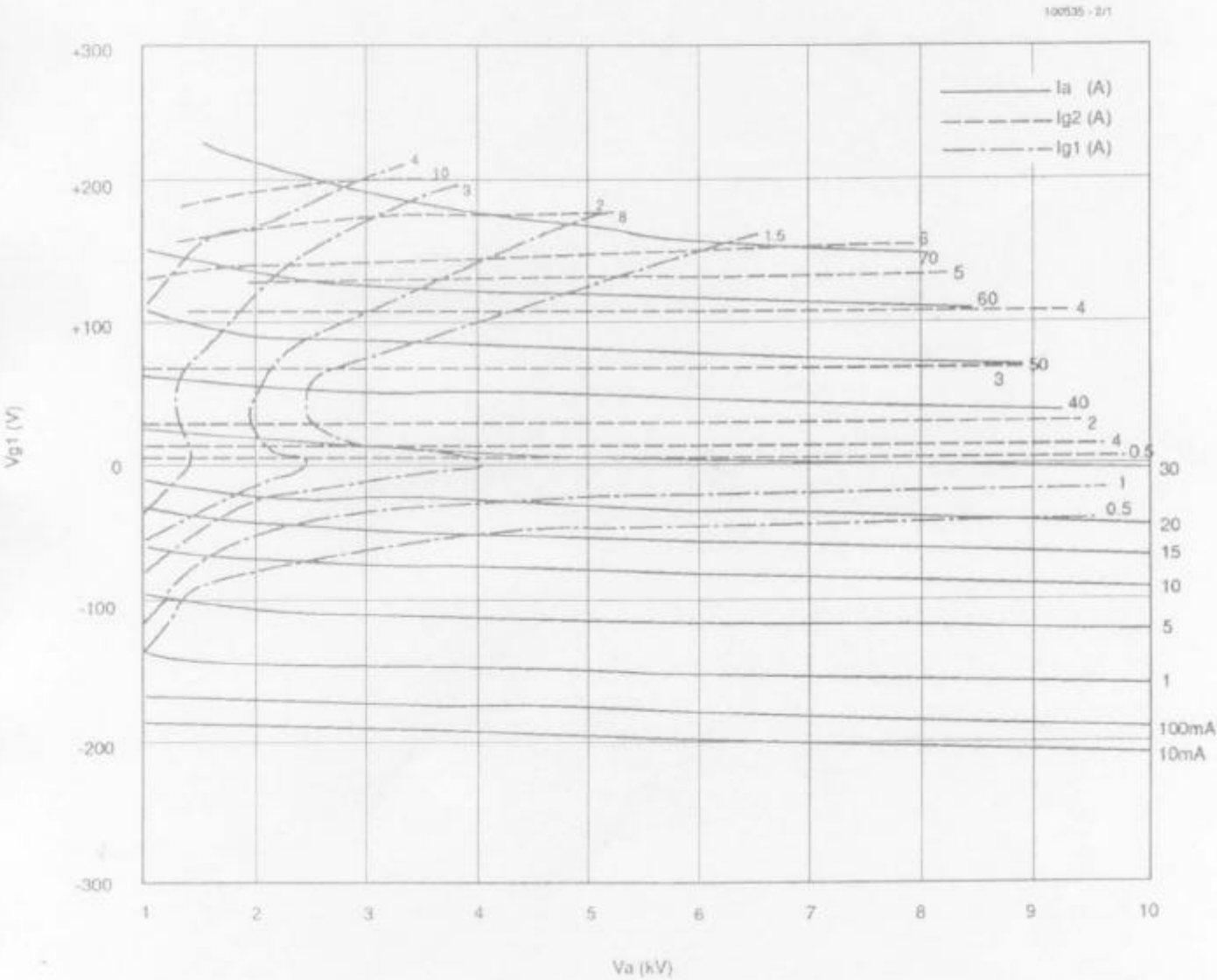
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CONSTANT CURRENT CHARACTERISTICS

VG2=1200V



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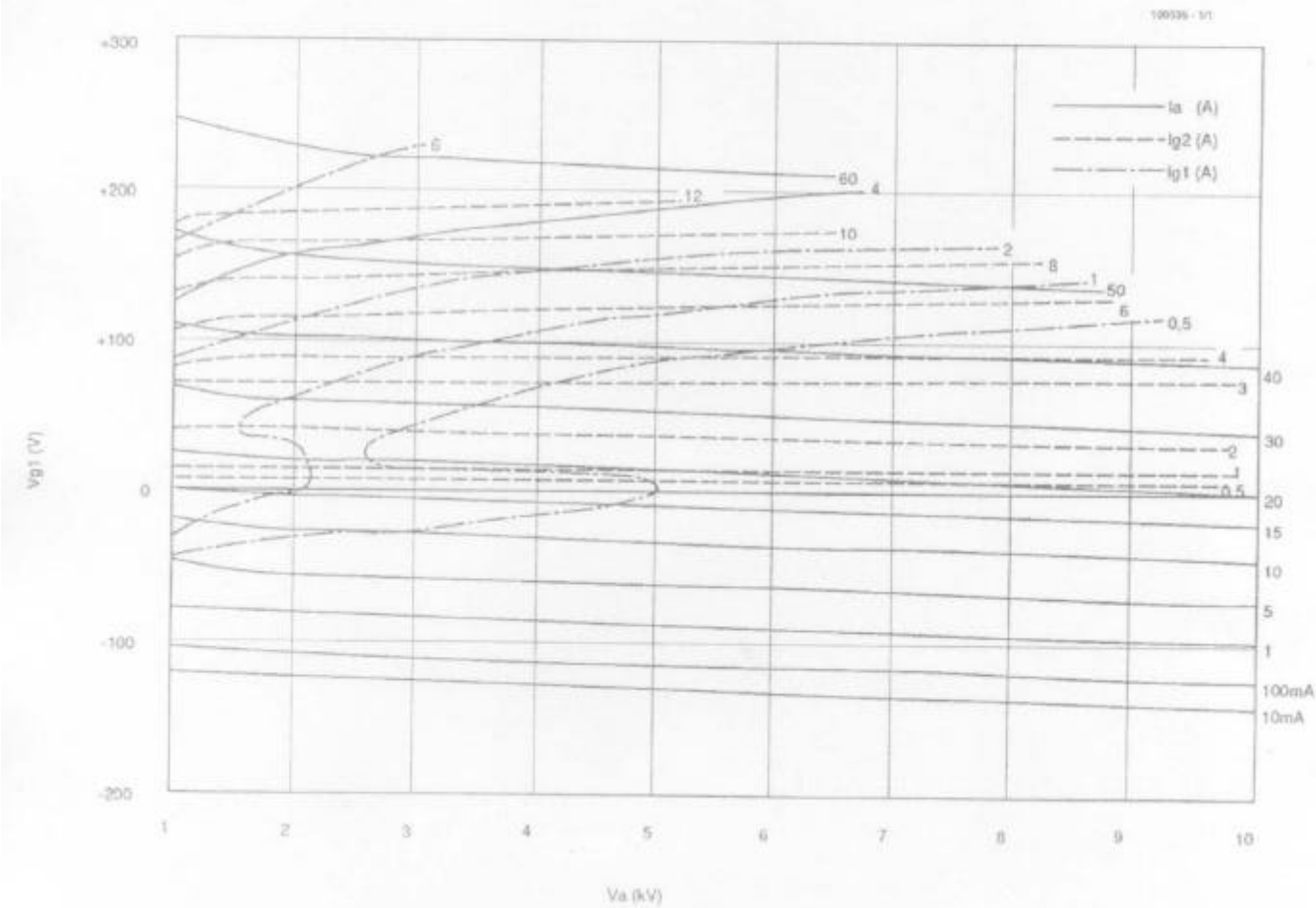
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CONSTANT CURRENT CHARACTERISTICS

VG2=800V



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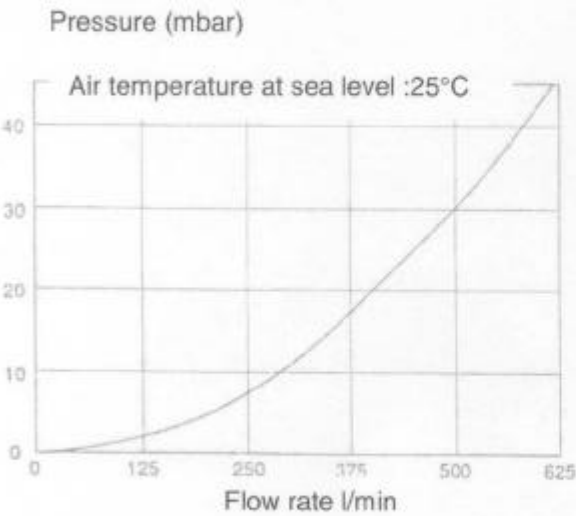
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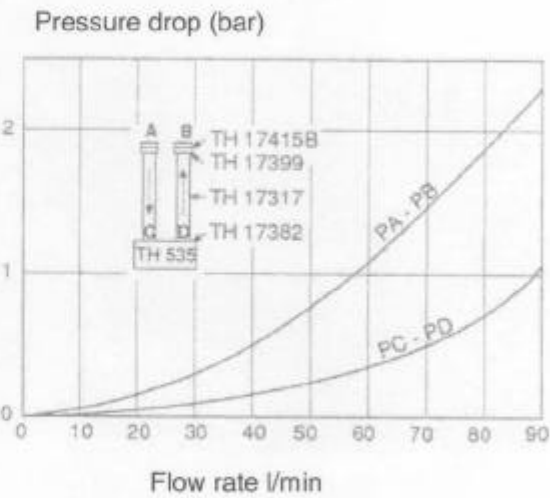
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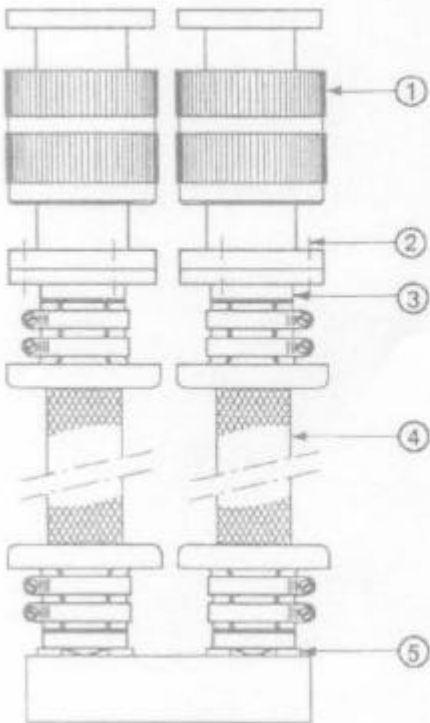
Air Cooling inlet pressure
With
Sochet TH18118K and TH18118G



Anode Cooling
Pressure drop vs Water flow



Cooling system connections



- ① Self obturating connectors TH17415B (x 2)
 - ② HM6 x 20 screw (6) / JZU WASHER (6)
 - ③ Antielectrolytic connectors TH17399 (x 2)
 - ④ Flexible insulating tubing TH17317 (x 2)
 - ⑤ Antielectrolytic connectors TH17382 (x 2)
- Inlet ' IN ' (BLUE)
- Outlet 'OUT ' (RED)

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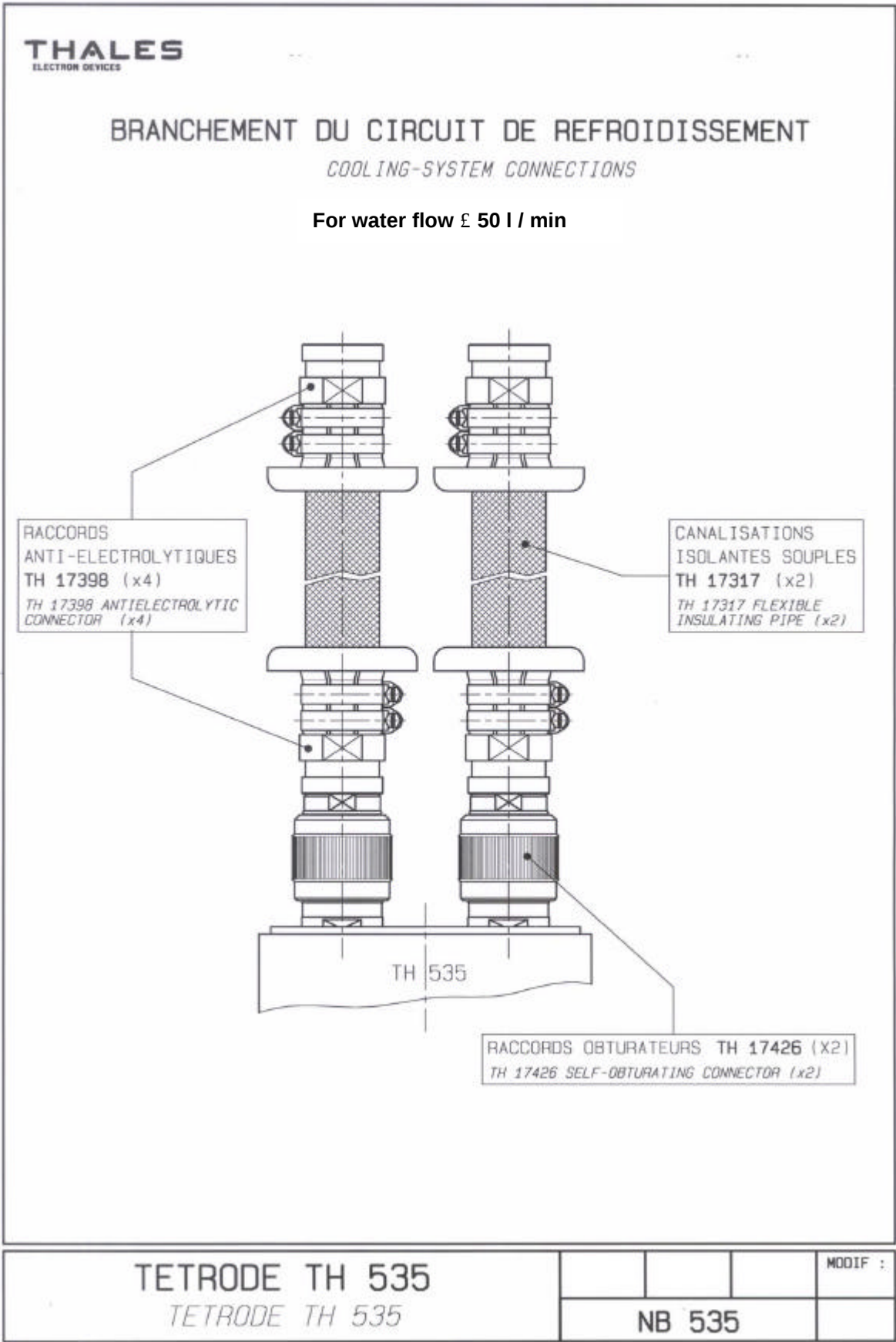
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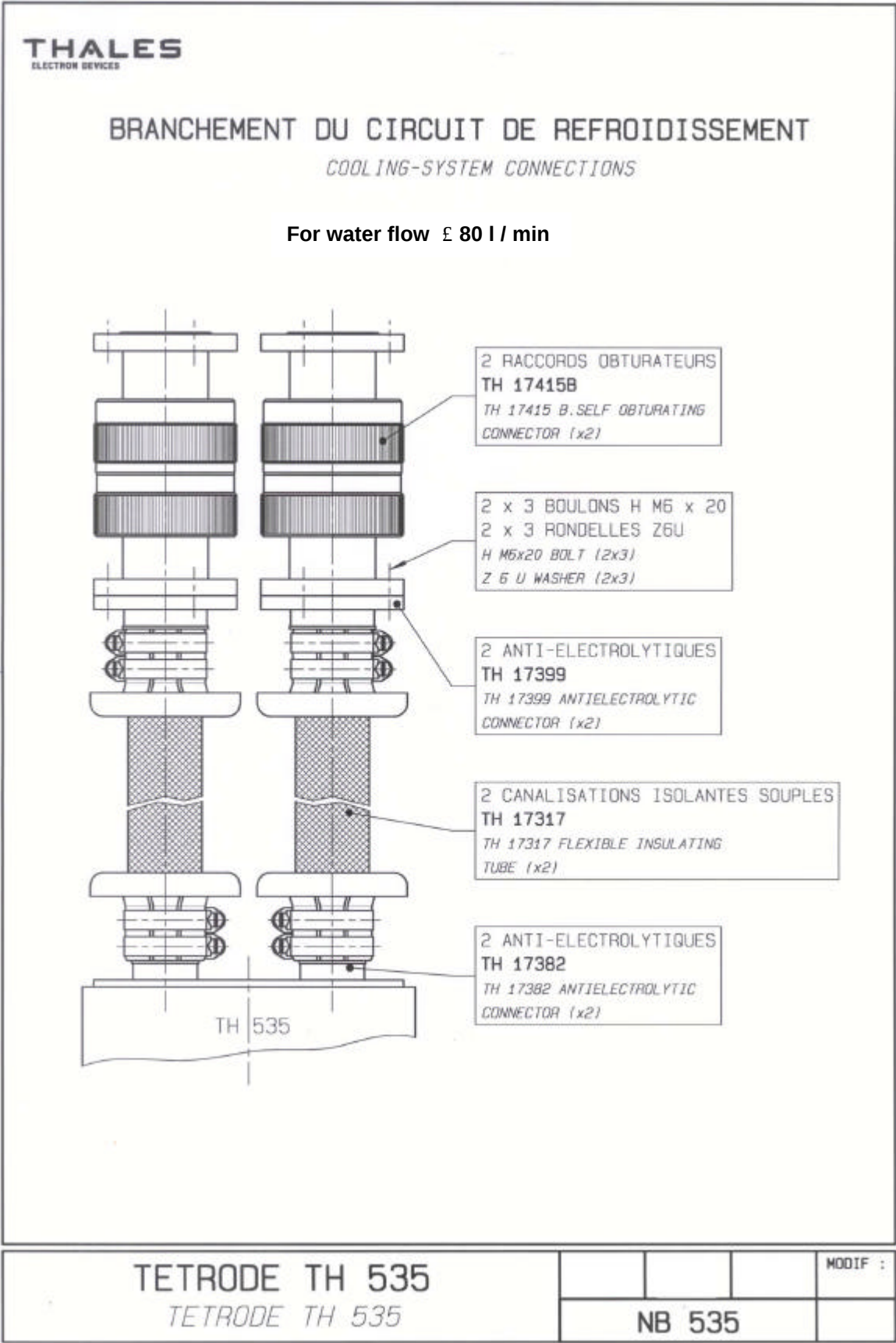
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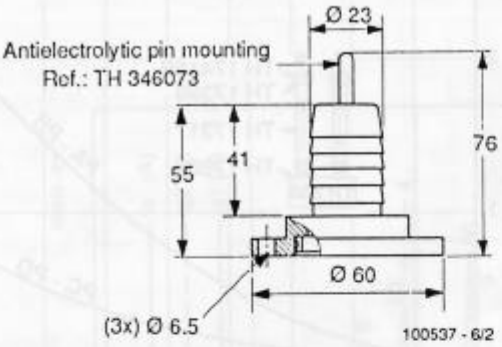
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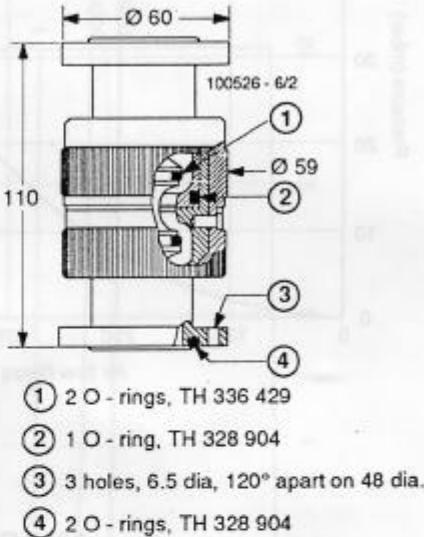
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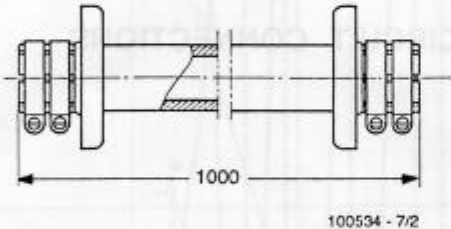
ANTIELECTROLYTIC CONNECTOR
TH 17399



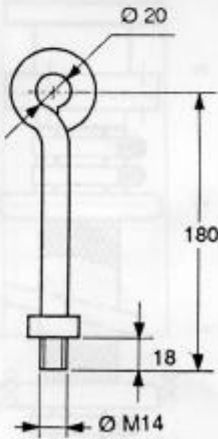
SELF OBTURATING CONNECTOR
TH 17415B



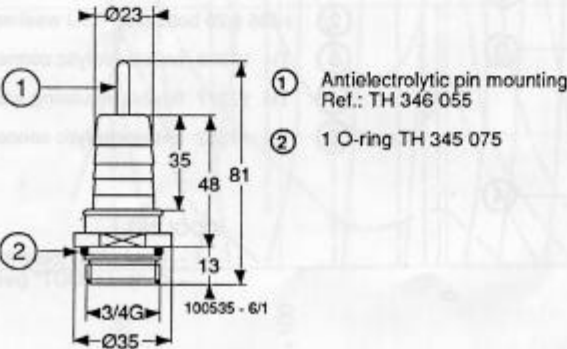
FLEXIBLE INSULATING TUBING
TH 17317



LIFTING DEVICE
TH 14218



ANTIELECTROLYTIC CONNECTOR
TH 17382



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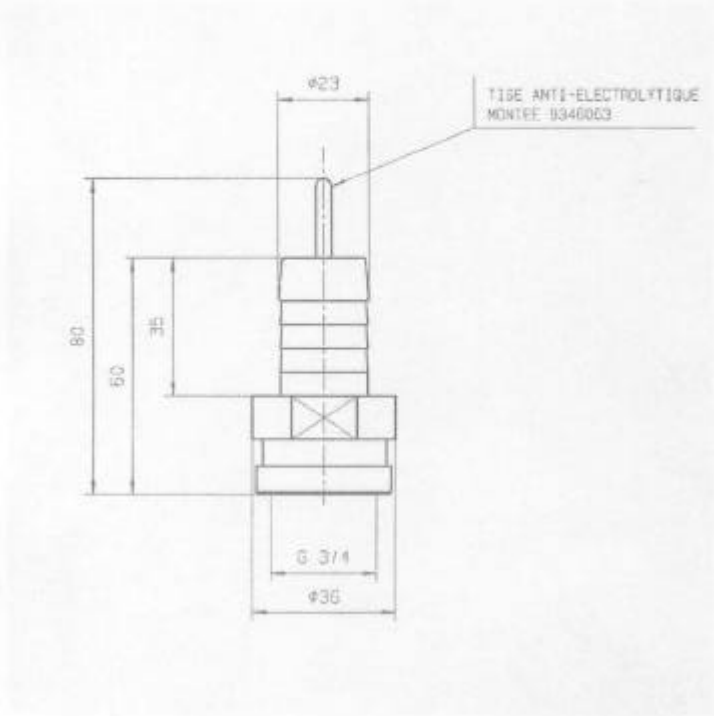
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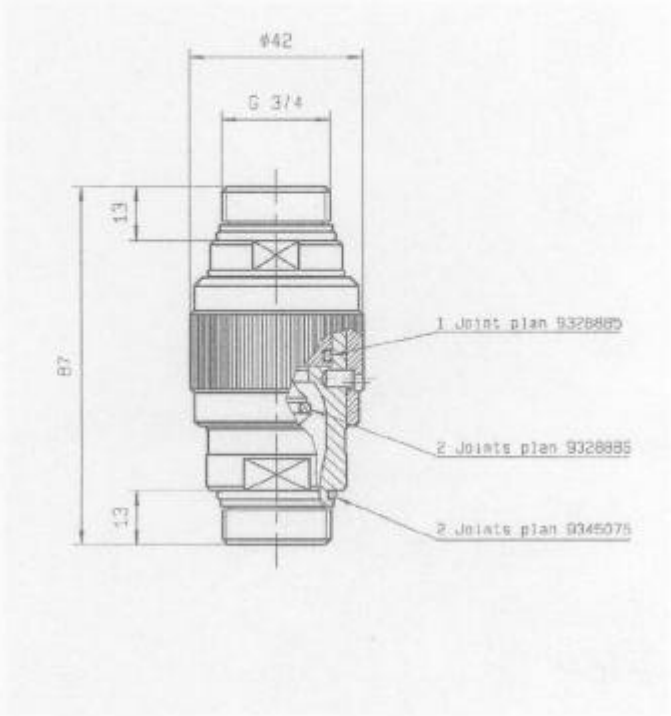
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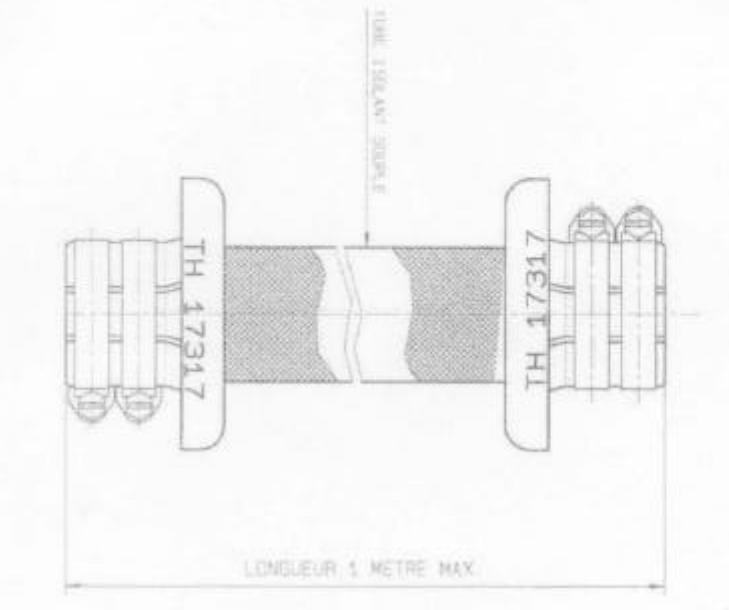
Antielectrolytic connector
TH 17398



Self obturating connector
TH17426



Insulating Tubing
TH 17317



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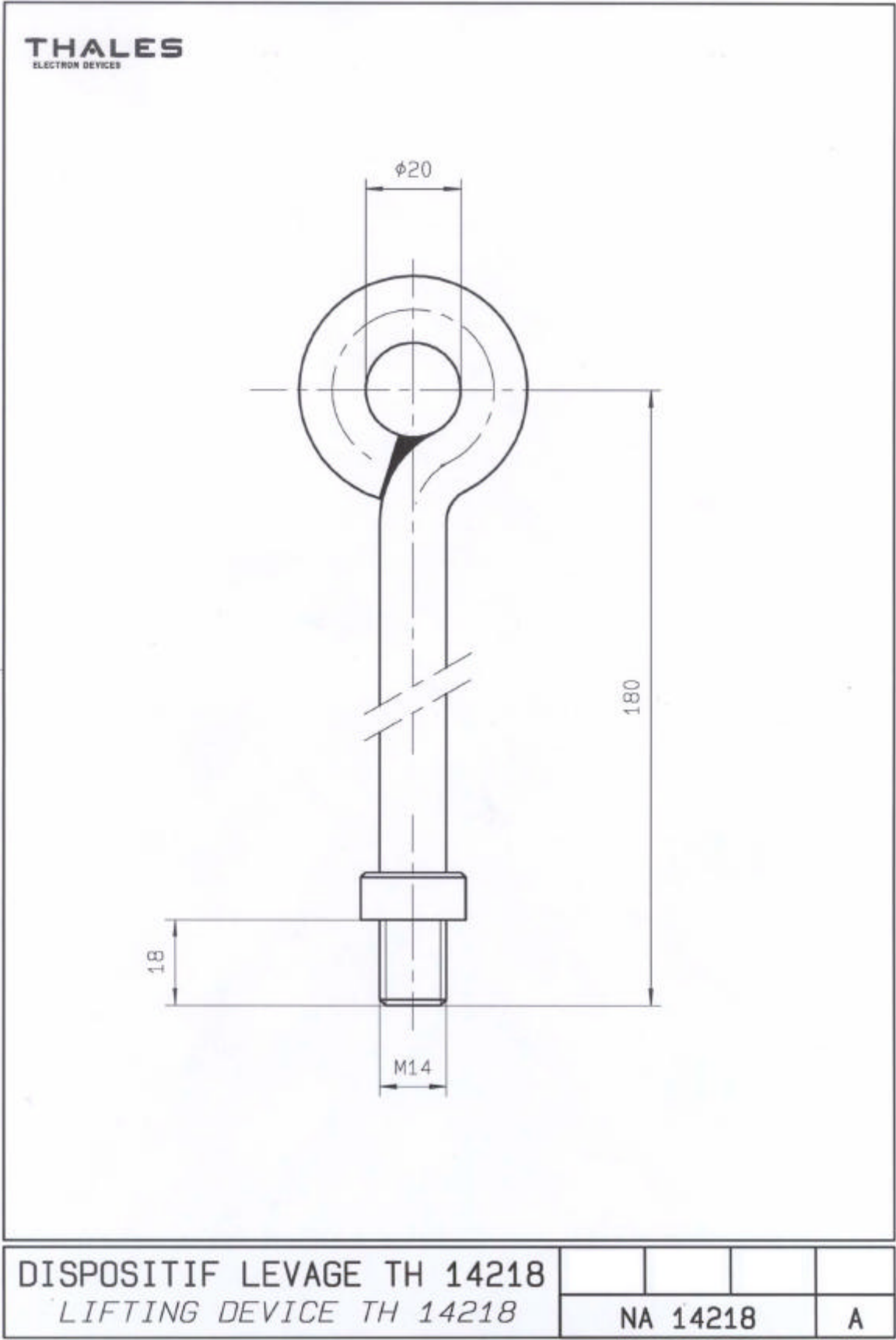
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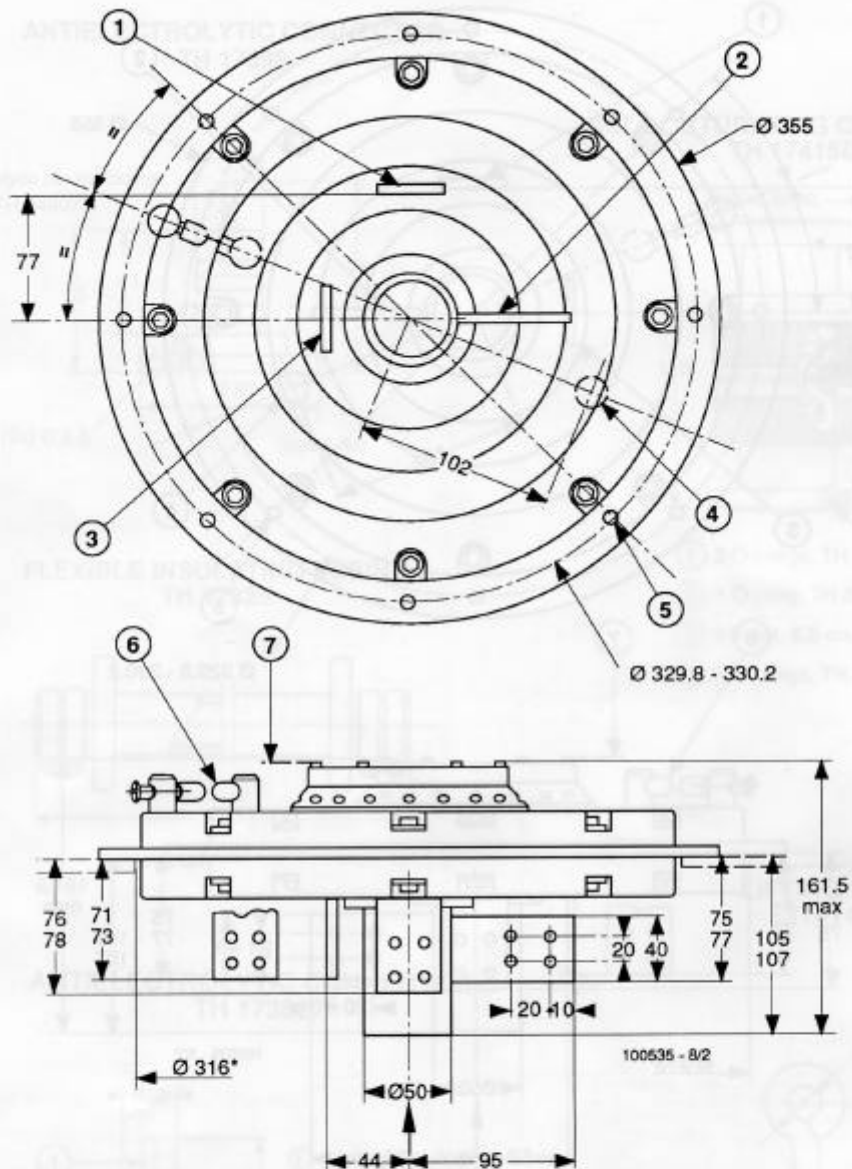


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SOCKET TH16118G

TH 16118G CONNECTOR



- ① Connection G1 - Connection lug** 4 holes Ø6.5 - thickness: 1.5
- ② Connection F } Connection lug**
- ③ Connection K } 4 holes Ø6.5 - thickness: 6
- ④ Connection G2 (M6)
- ⑤ 8 fastening holes for screws M6
- ⑥ Spark-gap
- ⑦ Bearing plane
- * Usefull passage
- ** Position of the holes identical on the 3 lugs

Dimensions in mm.



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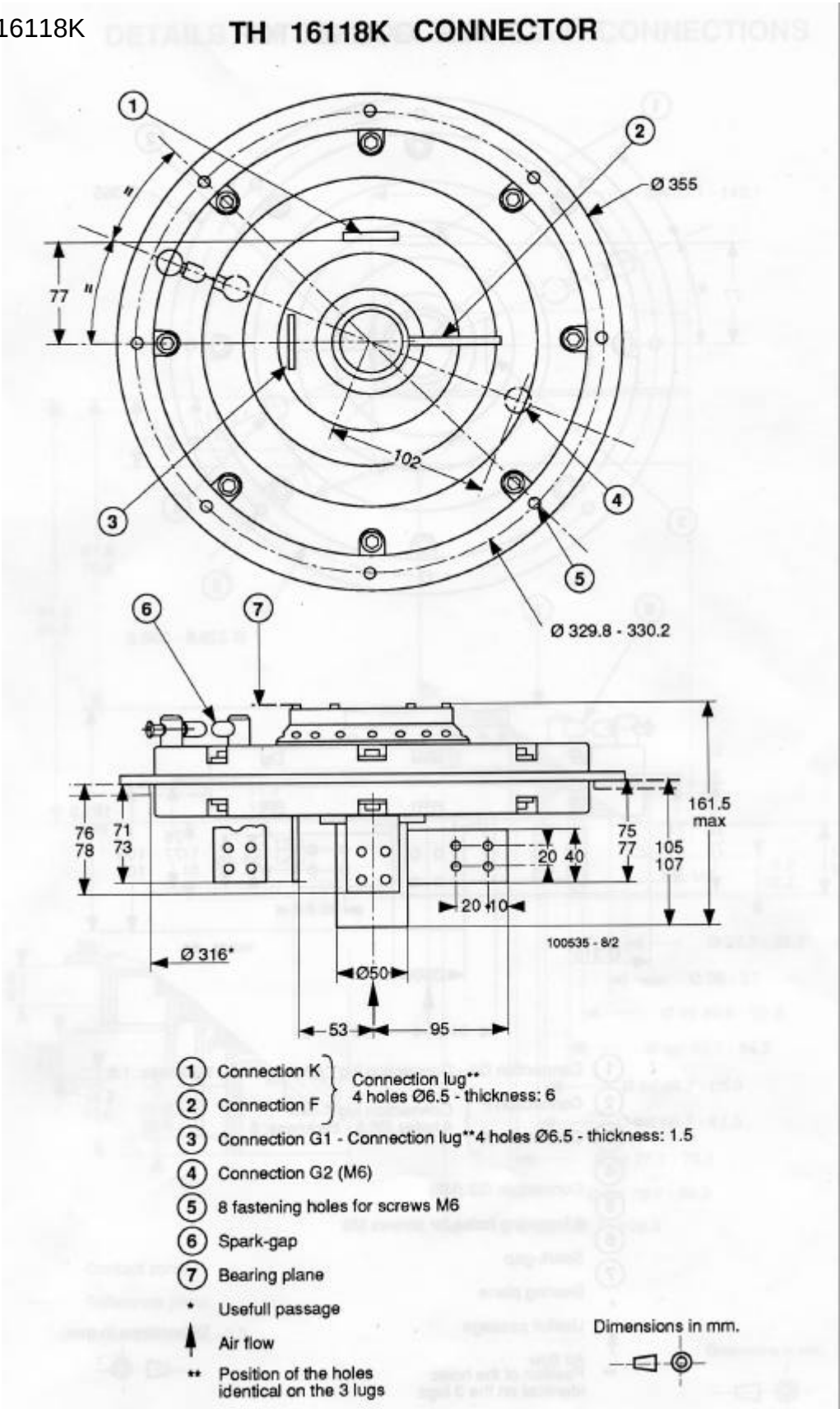
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SOCKET TH16118K

TH 16118K CONNECTOR



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