BTW 150-2, BTS 150-2

Super-Power Triode

The high power transmitting triode designed for an anode dissipation of 220 kW, is available in two sundry types depending on the cooling system:

1. <u>BTW 150-2</u> water cooled.
2. <u>BTS 150-2</u> vapour cooled.

The tube is suitable for use in transmitters as well as in industrial generators up to frequencies of 30 Mc/s.

General electrical Data:

Cathode thoriated tungsten, directly heated

Filament voltage		20	V ± 5%
Filament current	appr.	570	A
Filament, cold resistance		0,004	Ω
Mutual conductance (15 A/6 kV)	appr.	175	mA/V
Amplification factor	appr.	45	
Interelectrode capacitances: Grid to anode		2000 (1)	pF
Grid to cathode		450	pF
Anode to cathode		5	pF

Mechanical Data:

		BTW 150-2	BTS 150-2	
Tube cooling		Water	Vapour	
Temperature of glass bulb . .	max.	160	160	°C
Max. diameter of the bulb . .		310	310	mm
Overall length		756	762	mm
Weight net		81	96	kg
Weight gross	appr.	163	215	kg

MAXIMUM RATINGS

D.C. anode voltage (V_a)	18	kV
D.C. grid voltage (V_g)	- 1.5	kV
Peak cathode current (I_{kp})	300	A
Anode dissipation (P_a)	220	kW
Grid dissipation (P_g)	7	kW
Frequency (f)	30	Mc/s

"The Typical Operating Conditions" listed on pages 2/3 are only examples for average operating conditions. If a tube has to be operated under conditions different from those listed, even with higher values of certain parameters, the relevant operating data will be given on request.

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TYPICAL OPERATING CONDITIONS

Class B, A.F. Amplifier and Modulator

Max. Ratings:

D.C. anode voltage	15	kV
Signal d.c. anode current	42	A
Anode input power with signal	630	kW
Anode dissipation	220	kW

Typical Values for 2 Tubes in Push-Pull:

D.C. anode voltage		15	12.5	10	kV
D.C. grid voltage	appr.	-330	-280	-220	V
Peak a.c. grid voltage (G-G)		1965	1860	1740	V
Signal d.c. anode current		83	83	81	A
Zero signal d.c. anode current		5	5	5	A
D.C. grid current	appr.	17	17.5	18	A
Driving power	appr.	15	14.5	14	kW
Effective load resistance (anode to anode)		420	340	260	Ω
Power output		880	720	555	kW

Class C, R.F. Power Amplifier, Anode Modulated

Max. Ratings:

D.C. anode voltage	15	kV (f-20 MHz)
D.C. grid voltage	-1.5	kV
D.C. anode current	42	A
D.C. grid current	12	A
Anode input power	600	kW
Anode dissipation	150	kW
Grid resistance (tube not conducting)	1	kΩ

Typical Operating Carrier Conditions:

(for use with a max. modulation factor 1.0)

D.C. anode voltage		15	12.5	10	kV
D.C. grid voltage		-1150	-1090	-1030	V
Peak a.c. grid voltage		1950	1870	1820	V
D.C. anode current		36	36	36	A
D.C. grid current	appr.	[illegible]	9.6	9.6	A
Frequency		20	30	30	MHz

Grounded Cathode:

* Driving power	appr.	17	17	16.5	kW
Power output		435	355	275	kW

Grounded Grid:

* Driving power	appr.	79	77	75	kW
** Power output		500	415	330	kW

* Peak value for a modulation factor of 1.0
** Transferred power included

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[illegible]

Max. Ratings:

D.C. anode voltage	18	kV (f=20MHz)
D.C. grid voltage	-1,5	kV
D.C. anode current	45	A
D.C. grid current	12	A
Anode input power	650	kW
Anode dissipation	220	kW
Grid resistance (tube not conducting)	1	kΩ

Typical Operation:

D.C. anode voltage		18	15	12,5	kV
D.C. grid voltage		-775	-750	-700	V
Peak a.c. grid voltage		1460	1520	1470	V
D.C. anode current		35	41,5	41,5	A
D.C. grid current	appr.	8	10,5	10,5	A
Frequency		20	30	30	MHz

Grounded Cathode:

Driving power	appr.	11	14,5	14	kW
Power output		500	485	400	kW

Grounded Grid:

Driving power	appr.	55	69	67	kW
Power output		[illegible]	[illegible]	450	kW

Peak value for a modulation factor of 1.0
Transferred power included

Class C, R.F. Oscillator for Industrial Use
(D.C. anode voltage filtered)

Max. Ratings:

D.C. anode voltage	18	kV (f=20 MHz)
D.C. grid voltage	1,5	kV
D.C. anode current	45	A
D.C. grid current	12	A
Anode input power	650	kW
Anode dissipation	220	kW
Grid resistance (tube not conducting)	1	kΩ

Typical Operation (at full load)

Anode voltage		18	15	12,5	kV
Peak a.c. Grid voltage		1460	1520	1470	V
D.C. anode current		35	41,5	41,5	A
D.C. grid current	appr.	8	10,5	10,5	A
Grid dissipation		4,7	6,9	6,9	kW
Grid resistance	appr.	97	73	77	kW
Power output		490	470	430	kW
Frequency		[illegible]	30	30	MHz

The operating data for unfiltered d.c. voltage obtained from six-phase rectifier systems, can be taken as the same as that already given for a class C amplifier and oscillator utilizing filtered d.c. voltage.
"Operating conditions for higher power outputs on request"

INSTALLATION

Mounting: The power triode should be mounted vertically, the heater terminals (F) directed upwards; the deviation from the vertical being not more than 2 mm/m. Provision should be made to prevent subjecting the tube to appreciable vibration. The heater pins of the tube should be provided with connectors, having cooling vanes such as Brown Boveri HG 4C2573 R1 (fig. 1) to which a flexible stranded lead or a flexible metal strip has to be carefully connected. These connections, as well as the similar ones to the concentric grid terminal, should be of ample cross-section to prevent excessive heat production at high frequencies. All connections to grid and cathode must not be oxidised, should be clean and make good electrical contact. Otherwise, even with very small contact resistances, high voltage drops will occur with the relatively large currents involved. The heater pins and the ring are silverplated to provide first class electrical contact. Previous to making the connections, these terminals should be polished, but only with a soft cloth (but never with emery-paper). If necessary cleaning of the contacts may be carried out by means of industrial spirits on the cold tube. No mechanical strains should be imposed on the seals of the pins and the gridring. The installations of all wires and connections must be made so that they are flexible and will not be close to, or touch, the bulb. This precaution is necessary to avoid puncture of the glass from corona discharge.

1. The Water Cooling System of the BTW 150-2

The BTW 150-2 (fig. 1) must be operated only with the water cooling jacket type W 150a (fig. 2) in which the tube should be mounted with its anode pointing downwards.

The lower tubular connection on the jacket (I) serves as the cooling-water inlet and the upper lateral one as the outlet (O). By the appropriate shaping of the cooler, the cooling-water is made to circulate from the bottom to the top of the anode, thus keeping the latter uniformly cool. To prevent "scaling" of the anode, distilled water should be used whenever possible. Scaling hinders the cooling of the anode and can lead to the destruction of the tube as a result of overheating. It builds up a hard yellow spotted layer on the otherwise copper-red anode. Cooling-water with more than 8 degrees hardness should never be used directly. In many cases the scale can be removed with a 10 % hydrochloric acid solution or with trisodium phosphate. They should afterward be rinsed with distilled water. Special care should be taken with older tubes as their filaments may have become brittle. The best method, is, however, to use only distilled or deionized water.

Calcareous water should be cleaned by incorporating a water cleaner.

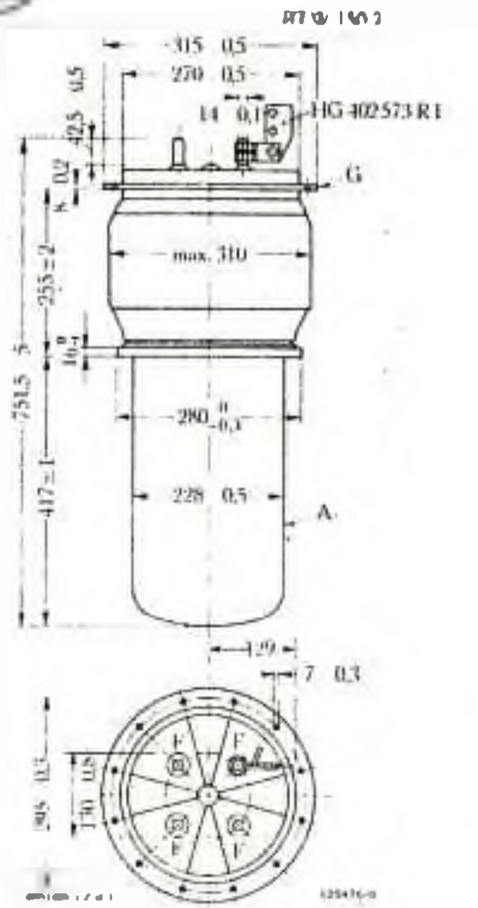

Fig. 1 BTW 150-2
(without water jacket)

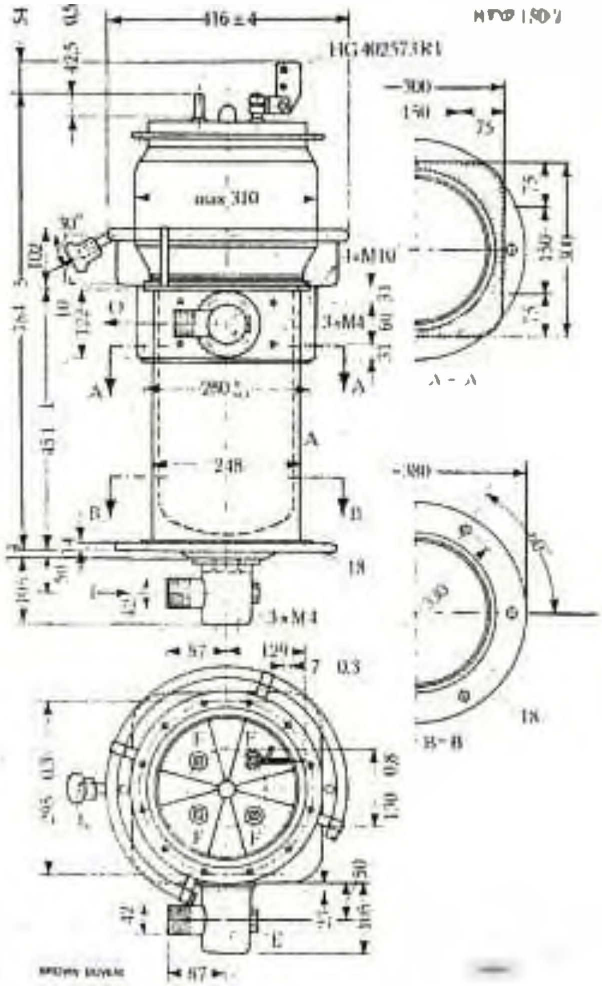

Fig. 2 BTW 150-2
mounted in its water-cooling
jacket W 15Ca

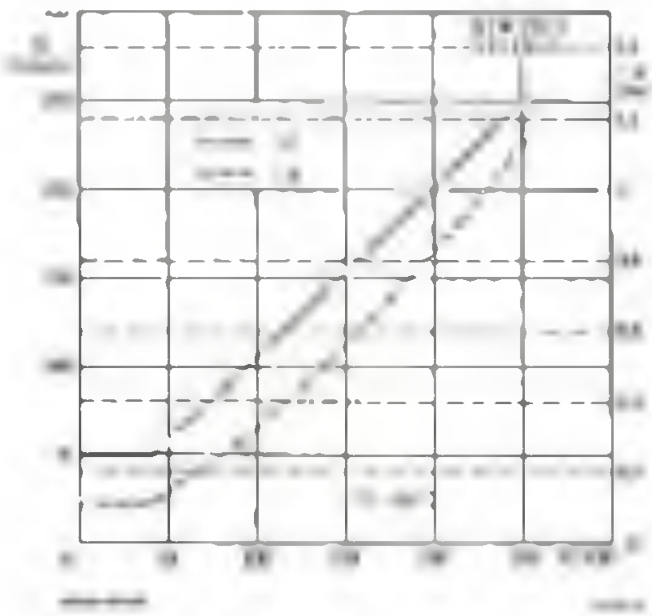

Fig. 3 Water-cooling curves

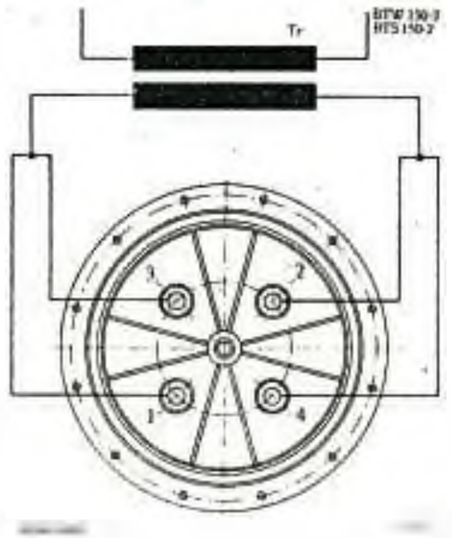

Fig. 4 Connection of the
filament circuit

The cooling jacket must be insulated, both the inlet and the outlet by a feed pipe system which carries the water through tubing chokes of insulating material so that the loss current is kept to a minimum. No electric field should influence this choke. For more detailed information see Brown Boveri Electron Tube Handbook, chapter 2.

The quantity of cooling water necessary is dictated by the power loss of the valve (anode + grid + heating). The quantity of cooling water required, Q, can be safely taken as about 220 litr's/min. The flow must be great enough in all cases to ensure that the temperature of the water at the outlet remains below 60 °C (140 °F). The cooling water quantity required is lowered, the smaller the value of Pa and the lower the inlet temperature of the water. This latter must in any case never exceed 30 °C (70 °F). The speed of the cooling water flow is also important. The necessary flow Q (litres/min.) and the pressure loss Δp can be taken from the cooling-curves fig.3.

The water cooling system should be interlocked with the power supply, so that neither filament nor anode voltage can be applied to the tube except while it is being cooled. The safety device should also shut off the power supply if during operation the cooling becomes insufficient. In as far as possible, each tube should be provided with the following devices:

1. A thermal fuse which upon actuation can also operate the aforesaid safety device.
2. (Temperature-sensitive resistance devices for the remote indication of temperatures.)
3. A relay-operated flow-meter (differential manometer according to the Venturi system).

Such a meter, which must depend on inlet and outlet pressures, operates if an obstruction occurs in the cooling water circuit. The tube local must be well ventilated, since the temperature of the tubes increases to undesirable values at high ambient temperatures.

To keep the before indicated tube temperatures within their limits in addition to the water cooling the following air cooling methods have to be applied:

a) By blowing a stream of cooling air (of about Q = 0.5 m^3/min and $p \approx 90$ mm H_2O) through both inlets (I_L) to the cooling-air ring bolted to the cooling jacket (fig.2.) The air leaves the ring through an annular series of small inner openings and the resultant air blast effectively cools the glass bulb and the grid ring.

b) By means of an air-stream which is blown at a rate of about Q = 2.5 m^3/min and $p \approx 90$ mm H_2O through an airguide HR 200977 A1 (fig. 5) the tube the tube header.

c) If necessary the grid metal-to glass seal has to be cooled too by means of an cooling-air ring.
The cooling air should be cleaned from impurities by filters.

The following maximum allowable temperatures should never be exceeded:

Glass-to metal seals:

of the gridring on the anode	150°C
of the cathode terminals	180°C
Glass bulb	160°C
Gridring	150°C
Cooling water inlet	60°C

The temperatures should be measured by means of a thermocouple and galvanometer or thermistor sensors.

2. The Vapour Cooling System of the BTS 150-2

The distinguishing feature of the vapour-cooled tube BTS 150-2 is its large copper anode radiator of special shape, allowing operation at more than twice the maximum anode dissipation of the conventinal water cooling (fig. 6). Cooling of the tube is uffected by allowing water to evaporate under the influence of the heat generated at the external anode. The water is in a closed circuit, which normally does not require any pump or rotating mechanism. The quantity and consumption of the cooling medium is extremely small. The circulation of the water, and thus the dissipation of the heat automatically adapts itself to the amount of heat which has to be dissipated. For this reason and on account of the high heat transfer coefficient, a higher Pa max. can be allowed than with other cooling systems. Simple safety devices are quite sufficient. Further indications see Brown Boveri Electron Tube Handbook, chapter 2.

Additional air cooling of the header and the grid ring is necessary and has to be carried out in the same way and with the same data indicated for the water cooling; also the air-guide (fig. 5) has to be provided.

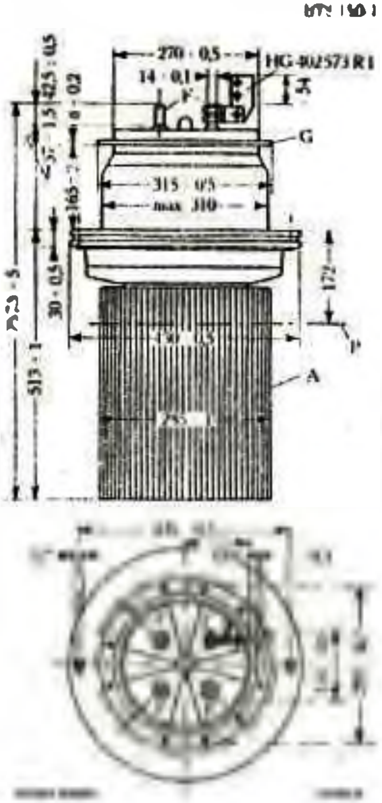

Fig. 6 Vapour cooled tube type BTS 150-2

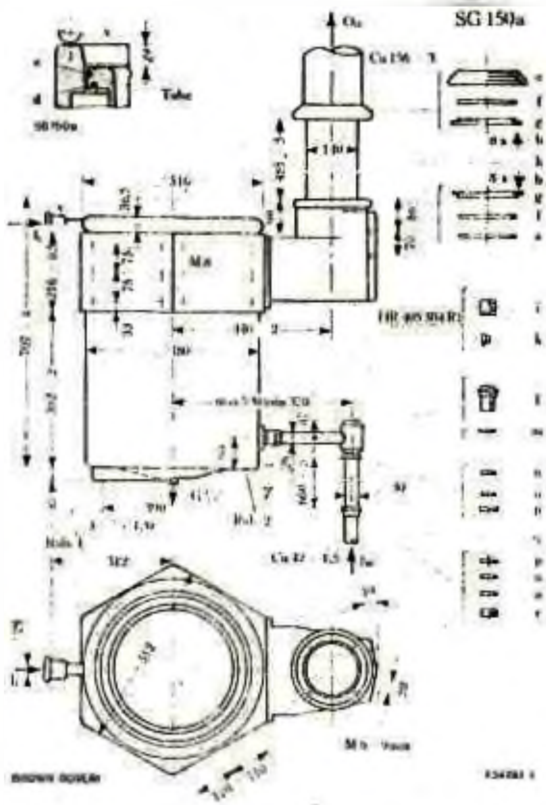

Fig. 7 Boiler SG 150a Legend see page 9

Fig. 5 Air guide for Cooling of the tube header ERXC 7761
I - air inlet, O - air outlet
F - Filament pins, G - Grid

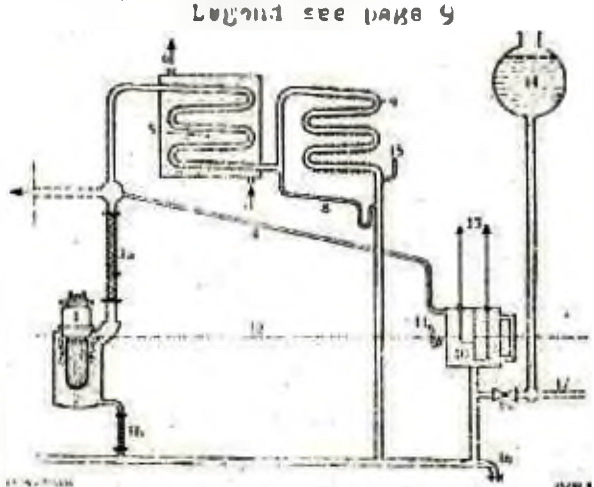

Fig. 8 Principle of the vapour cooling system. (Legend see page 9)

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Details of the Boiler type SG 150a shows Fig. 7 with the following explanation of the parts belonging to it:

a - ring	HR 405 142 P1
b - cylinder head screw	HR 100 364 P3
c - ring	HR 300 337 P1
d - ring	HR 404 899 P1
e - spiral gasket	HR 404 901 P1
f - gasket	HR 404 881 P1
g - pressure ring	HR 300 235 P1
h - insulating tubing for vapour outlet	HR 404 941 P1
i - connection nut	HR 405 304 P1
k - clamping ring	HR 405 304 P2
l - anti electrolytic-connection	HR 404 869 R1
m - gasket	HR 404 892 P1
n - gasket	HR 404 894 P1
o - pressure ring	HR 404 895 P1
p - nut	HR 404 896 P1
q - insulating glass tubing (below)	HR 404 893 P1
r - pressure sleeve	HR 404 995 P1
s - air cooling ring	HR 200 985 R1

I_W - Cooling water inlet

O_D - Vapour outlet

I_L = Air inlet

In Fig. 8 complete vapour cooling system is illustrated. Belonging to the systems are the following parts:

1 - Brown Boveri vapour-cooled tube type BTS 150-2
2 - Boiler type [illegible] 150a (Fig.7) or simplified system SGK 150a (Fig. 9)
3a - Insulating glass tubing, vapour outlet
3b - Insulating glass turbing, water entrance
4 - Equalizing pipe, with min. inclination of 5 cm/m
5 - Water condenser (heat exchanger)
6 - Secondary hot-water circuit of the heat exchanger outlet (for space heating)
7 - Inlet
8 - Condensate return pipe
9 - additional condenser for cooling by air (radiator with a fan) only where necessary
10 - Water-level monitoring tank, should be mounted near by the transmitting tubes with two levels (fig. 10)
11 - Overflow with siphon
12 - Water level required, hold constant ("P" see also fig.6)
13 - To protection unit (which acts as soon as "12" changes)
14 - Water reservoir
15 - Air outlet
16 - Water drain cock
17 - Connection for a further cooling system
19 - Check valve remote controlled

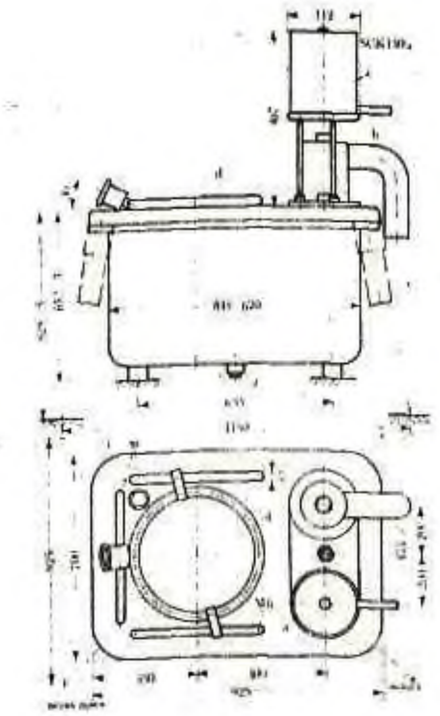

Fig. 9

Boiler with integral condenser SGK 150a (Simplified system)

Fig. 11

Lifting apparatus for BTS 150-2

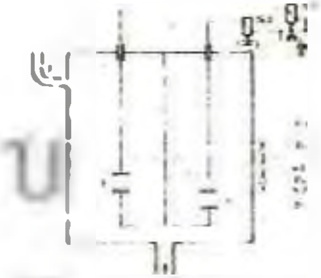

Fig. 10

Water-level monitoring tank

Mode of operation of the Water-level Monitoring Tank (Fig. 10)

Water level marked "P Normal" is the water level which must be held constant during operation. The level to which the tube anode has to be covered with water differs from type to type. It is marked by the letter "P" in the dimensional outline of each tube type. If the level has fallen to P_{min1} the electric circuit is interrupted between electrodes No.4 and as a result a signal is produced in the protection unit by the contact S1 1. Should the level drop down to mark P_{min2} the current is interrupted between electrodes No.5 and contact S1 2 of the protection unit immediately disconnects the power supply to the tube. An increase of the water level is only allowed up to mark "Pmax". The overflow with siphon (2) prevents this mark from being exceeded. 1 - equalising pipe, 3 - condensed water inlet.

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General Indications

Filament Circuit. The filament is of thoriated tungsten and the heater voltage should be adjusted to the nominal value of 20 V ± 5 % at full load. At very small load only, the filament voltage may be reduced by up to -10 %, but only to such an extent that the peak cathode current is lower than 150 A. Underheating of a thoriated tungsten cathode is very dangerous and could render it inoperative. Overheating should be avoided in the interest of maintaining long live. A suitable precision voltmeter (moving-magnet instrument with min. 1 % of accuracy or better) should be connected directly across the filament terminals to check the voltage. Moving-coil instruments with rectifiers are not recommended. The filament circuit has to be connected to the 4 filament-pins (1-4) as indicated in fig. 4.
The initial filament surge current is harmful to the tube and suitable means should therefore be provided to limit this surge current. The filament voltage should also be increased gradually to nominal value when starting operating. This may be done in 2-3 steps with a tapped transformer, with damping resistors or a high-inductance transformer.

The grid and anode circuit-return should always be connected to the central tap of the filament transformer if a.c. heating is employed.

In intermittent operation it is recommended to leave the filament voltage in operation at nominal value during standby periods up to 30 minutes and at the reduced value of 16 V during standbys up to 120 minutes. The filament may be switched off during breaks of more than 2 hours. When resuming operation, the above instruction for starting operation should be observed.

In R.F. operation all 4 filament leads should each be shunted with a non-inductive capacitor of 200-1000 pF, so that all the filament wires have equal r.f. load.

Grid Circuit: The grid terminal designed as a broad circular flange is favourable for operating conditions prevailing at high radio frequencies and in grounded grid circuits. 8 holes are provided on the circumference of the grid flange to which the connecting flexible metal strips should be screwed on. The connections must ensure a good contact and must not exert any mechanical strain on the flange and its glass-to-metal seals. In r.f. operation, all of the 8 holes of the grid flange should be connected so that the r.f. currents are evenly distributed over the whole area of the grid ring.

If strong unilateral magnetic fields occur in vicinity of the tube there is a risk of uneven distribution of the r.f. current on the circumference of the flange, despite symmetrical grid connection. In those cases only by means of an appropriately designed grid circuit an even distribution of the r.f. current can be restored.

when a new tube is first taken into operation the temperature should be measured exactly around the whole circumference of the flange.

A means of over voltage protection such as an accurately adjusted spark gap between grid and earth is always to be recommended in the grid circuit of large tubes.

Anode Circuit: The anode voltage should be applied about 1 to 2 minutes after the filament has reached its rated voltage and operating temperature. The delay for the anode voltage is best introduced with a time-lag relay.

An over-current relay with 50 ms seconds operating time or alternatively a quick-acting fuse should be provided as protection against over-load. The anode voltage is only allowed to be switched on after a damping period of minim. 0.1 sec.

A protecting resistor of 25 ohms should be connected in the anode circuit of the tube. This resistor will damp sudden short-circuit peaks which could occur in the period during which the over-current relay takes to operate.

Efficient protection against faults in the r.f. section of the transmitter stages is afforded by high voltage rectifiers utilising grid controlled HV rectifier tubes (thyratrons) e.g. TQ 81, TQ 91, which allow to control continuously the d.c. supply voltage and protect the transmitting tubes by rapid interruption in case of short circuits and backfires.

Each adjustment and tuning of a transmitter should only be carried out at reduced anode voltage, e.g. by connecting an appropriate anode resistor in the anode lead which is afterwards short-circuited.

It is recommended to check periodically the temperature on the anode-to-glass seal which should never exceed [illegible].

A new tube should be initially heated for 20 minutes at rated filament voltage before applying any other voltage and only then the anode voltage should be applied and gradually brought up to nominal value. Transmitting tubes held in stock should be put in operation in the above manner during the first 6 months and remain in operation at full load for at least one hour.

Care should be taken with tubes having reached more than 1000 operating hours as their filament becomes brittle with increasing operating hours. Therefore the tube should not be subjected to shocks during handling and storage.

The high weight of the tube (BTW 150-2 = 41 kg, BTS 150-2 = 96 kg) imposes the necessity to heave up and transport the same by means of a lifting apparatus as shown in fig. 11.
type HR 100 796 R1 for BTW 150-2 and type HR 200 854 R1 for BTS [illegible].

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Operation

Class B, AF Amplifier and Modulator. The negative grid voltage may be either produced by a battery or by a rectifier of good voltage stability, potentiometers to adjust the voltage for each tube separately should be provided. No high resistance grid voltage sources should be employed. The values of d.c. grid voltage given in the data are to be considered as approximative.

Class C, Anode Modulated RF Amplifier. The modulating voltage in class C amplifiers is imposed on the output and applied to the anode in series to the DC anode voltage.

Battery, rectifier, grid resistor or cathode resistor or a combination of them may be employed to produce the negative grid voltage which is not particularly critical in this service. The most recommended means is a combination of grid resistor and rectifier, since it offers the best protection against overloads and is simple to provide.

Class C, Unmodulated RF Amplifier. In this class of service of either the grounded-filament or the grounded-grid type, the tube may be supplied with bias by any convenient method. Best results regarding protection against overloading are obtained with a combination of grid resistor and rectifier. At the maximum rated anode voltage of 10 kV a fixed bias of at least -350 volts should be used.

For industrial use, as oscillator e.g. in r.f. industrial generators, with the unavoidable variable loading, the grid-bias voltage is best produced by a grid resistor, which thus alternately varies the voltage with change of load, within known limites. Grid current and grid r.f. voltage should thus, at full load, be kept at about half the safe maximum value, so that no increase beyond the maximum allowable grid dissipation can arise at no load.

Parasitic oscillations can be suppressed by means of a non-inductive resistor of 30-50 ohms connected as near as possible to the grid. Higher anode voltages with the resultant possibility of small anode currents are preferable in order to obtain a long tube life..

Storage. In the interest of timely replacement claims in case of transport damages, it is advisable to inspect each tube immediately upon arrival and test it electrically in the equipment for which it is intended. Storage of the tube is best done in dry places where no great temperature fluctuations occur. The tube is stored with advantage in its original packing.

Maximum Ratings. Each of the "Maximum Ratings" included all the abbreviated values indicated with "max.", gives the limiting value which cannot be exceeded without seriously affecting tube life. For additional hints see Brown Boveri Electron Tube Handbook.