ASEA BROWN BOVERI

ABB Infocom Ltd
Communications and Information Systems
Electron Tubes Sales Department

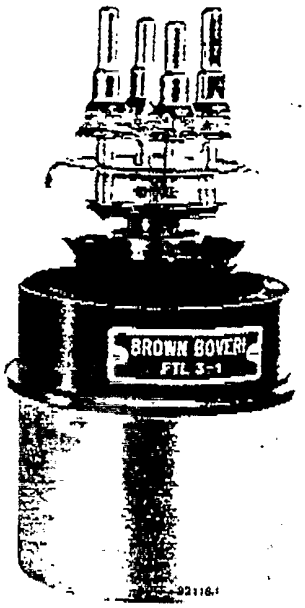
CH-5401 Baden/Switzerland

Phone: (CH) 056/75 20 11
Telex: 828 291 11 ab ch
Telefax: (CH) 056/22 95 57

# FTL 3-1/FTL 3-2/FTW 3-1 Industrial Triode Aircooled or Watercooled

HR 90461

FTL 3-1/FTL 3-2/FTW 3-1 Industrial Triode Aircooled or Watercooled




FTL 3-1

The FTL 3-1/FTL 3-2 is a transmitting triode the anode of which is fitted with a radiator, and cooling is obtained by forced air. The type FTW 3-1 is watercooled. These tubes are capable of delivering a max. output power of 7 kW, Class C, oscillator at 30 Mc/s. As a result of careful and robust construction they can be used in a wide field of industrial applications. The types FTL 3-1 and FTL 3-2 are distinguished only by their different radiators and anode dissipations.


FTL 3-2

## General Data:

Cathode thoriated tungsten, directly heated

| | | | |
|---|---|---|---|
| Filament voltage | appr. | 12 | V $^{+5}_{-10}$ % |
| Filament current | max. | 26 | A |
| Max. filament starting current | | 100 | A |
| Filament cold resistance | appr. | 0.045 | Ω |
| Mutual conductance (1 A/3 kV) | appr. | 13 | mA/V |
| Amplification factor | | 28 | |
| Interelectrode capacitances: Grid to anode | | 12 | pF |
| Grid to cathode | | 15 | pF |
| Anode to cathode | | 0.35 | pF |

## Mechanical Data:

| | | FTL 3-1 | FTL 3-2 | FTW 3-1 | |
|---|---|---|---|---|---|
| Tube cooling | | forced air | | water | |
| Temperature of glass bulb | max. | 160 | 160 | 160 | °C |
| Max. diameter | | 102 | 123 | 77 | mm |
| Overall length | max. | 200 | 202 | 182 | mm |
| Weight net | appr. | 3 | 4.5 | 0.5 | kg |
| Weight gross | appr. | 6.5 | 8 | 2.5 | kg |
| Weight of the cooling jacket (K 3) | | | | 0.5 | kg |

## MAXIMUM RATINGS:

| | FTL 3-1 | FTL 3-2/FTW 3-1 | |
|---|---|---|---|
| D.C. anode voltage | 7 | 7 | kV |
| D.C. grid voltage | -1 | -1 | kV |
| Peak cathode current | 10 | 10 | A * |
| Anode dissipation | 3.5 | 5 | kW |
| Grid dissipation | 150 | 150 | W |
| Frequency | 60 | 60 | Mc/s |

* Max. value of 15 A is allowed if the filament voltage is stabilized within ± 5 %.

## TYPICAL OPERATING CONDITIONS

### Class B, A.F. Amplifier and Modulator

**Max. Ratings:**

| | | |
|---|---|---|
| D.C. anode voltage | 7 | kV |
| Signal d.c. anode current | 1.7 | A |
| Anode input power with signal | 9 | kW |
| *Anode dissipation | 3.5 (5) | kW |

**Typical Values for 2 Tubes in Push-Pull:**

| | | | | | |
|---|---|---|---|---|---|
| D.C. anode voltage | | 6 | 5 | 4 | kV |
| D.C. grid voltage | appr. | -215 | -180 | -145 | V |
| Peak a.f. grid to grid voltage | | 1080 | 1050 | 1040 | V |
| Zero signal d.c. anode current | | 0.3 | 0.3 | 0.3 | A |
| Max. signal d.c. anode current | | 2.8 | 3 | 3.3 | A |
| Grid current | appr. | 0.36 | 0.44 | 0.5 | A |
| Driving power | appr. | 180 | 210 | 230 | W |
| Effective load resistance (A-A) | | 4.8 | 3.6 | 2.6 | kΩ |
| Max signal power output | | 11.5 | 10 | 8.5 | kW |

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

(Carrier conditions per tube for use with a maximum modulation factor of 1.0)

**Max. Ratings:**

| | | |
|---|---|---|
| D.C. anode voltage | 5.5 | kV |
| D.C. grid voltage | -1 | kV |
| D.C. anode current | 1.2 | A |
| D.C. grid current | 0.4 | A |
| Input power | 5.5 | kW |
| *Anode dissipation | 2.5(3.3) | kW |

**Typical Operation:**

| | | | | |
|---|---|---|---|---|
| D.C. anode voltage | | 5 | 4 | kV |
| D.C. grid voltage | | -305 | -330 | V |
| Peak a.c. grid voltage | | 700 | 670 | V |
| D.C. anode current | | 1.1 | 1.1 | A |
| D.C. grid current | appr. | 0.2 | 0.2 | A |
| Driving power | appr. | 130 | 130 | W |
| Power output | | 4.3 | 3.3 | kW |
| Frequency | | 30 | 30 | Mc/s |

### Class C, RF, Power Amplifier Unmodulated or FM

**Max. Ratings:**

| | | |
|---|---|---|
| D.C. anode voltage | 7 | kV |
| D.C. grid voltage | -1 | kV |
| D.C. anode current | 1.75 | A |
| D.C. grid current | 0.4 | A |
| Anode input power | 10 | kW |
| *Anode dissipation | 3.5 (5) | kW |

Typical Operation:

| | | | | | |
|---|---|---|---|---|---|
| Anode voltage | | 6 | 5 | 4 | kV |
| D.C. grid voltage | | -450 | -425 | -395 | V |
| Peak r.f. grid voltage | | 880 | 875 | 845 | V |
| Anode current | | 1.55 | 1.75 | 1.75 | A |
| Grid current | appr. | 0.27 | 0.3 | 0.26 | A |
| Driving power | appr. | 225 | 240 | 210 | W |
| Power output | | 7 | 6.3 | 4.5 | kW |
| Frequency | ≦ | 30 | 30 | 60 | Mc/s |

Class C, R.F. Oscillator

(with filtered d.c. anode voltage)

Max. Ratings:

| | | |
|---|---|---|
| D.C. anode voltage | 7 | kV |
| D.C. grid voltage | -1 | kV |
| D.C. anode current | 1.75 | A |
| D.C. grid current | 0.4 | A |
| Anode input power | 10 | kW |
| *Anode dissipation | 3.5(5) | kW |

Typical Operation: (at full load)

| | | | | | |
|---|---|---|---|---|---|
| D.C. anode voltage | | 6 | 5 | 4 | kV |
| Peak r.f. grid voltage | | 700 | 660 | 630 | V |
| D.C. anode current | | 1.6 | 1.6 | 1.6 | A |
| D.C. grid current | appr. | 0.22 | 0.22 | 0.23 | A |
| Grid resistance | appr. | 1.45 | 1.2 | 1 | kΩ |
| Grid dissipation | | 75 | 76 | 77 | W |
| Power output | | 6.6 | 5.4 | 4 | kW |
| Frequency | | 30 | 30 | 60 | Mc/s |

Class C, R.F. Oscillator for Industrial Use

with anode voltage from single-phase full-wave rectifier without filter

Max. Ratings:

| | | |
|---|---|---|
| Anode voltage | 6.3 | kV |
| D.C. grid voltage | -1 | kV |
| **Anode current | 1.55 | A |
| **Grid current | 0.4 | A |
| Anode input power | 10 | kW |
| *Anode dissipation | 3.5(5) | kW |

* Values in brackets refer to FTL 3-2/FTW 3-1
** Average values

◀

* Values in brackets refer to FTL 3-2/FTW 3-1
All other ratings (except for anode dissipation) are valid for FTW 3-1, FTL 3-1 and FTL 3-2.

Typical Operation: (at full load)

| | | | | | |
|---|---|---|---|---|---|
| A.C. anode voltage (R.M.S. value) | | 2 x 6 | 2 x 5 | 2 x 4 | kV |
| **Anode voltage | | 5.4 | 4.5 | 3.6 | kV |
| **Anode current | | 1.4 | 1.55 | 1.6 | A |
| **Grid current | appr. | 0.2 | 0.2 | 0.23 | A |
| Grid resistance | appr. | 2 | 1.8 | 1.5 | kΩ |
| Grid dissipation | | 80 | 90 | 100 | W |
| Power input | | 9.4 | 8.6 | 7.1 | kW |
| Anode dissipation | | 2.8 | 3.1 | 3 | kW |
| Power output | | 6.7 | 5.6 | 4.4 | kW |
| Frequency | ≦ | 30 | 30 | 60 | Mc/s |

Class C, R.F. Oscillator for Industrial Use

self rectification with a.c. anode voltage supply

Max. Ratings:

| | | | |
|---|---|---|---|
| Transformer voltage (R.M.S.) | 8 | kV | |
| D.C. grid voltage | -1 | kV | |
| **Anode current | 0.95 | A | |
| **Grid current | 0.25 | A | |
| Anode input power | 6.2 | kW | |
| *Anode dissipation | 3.5(5) | kW | |

Typical Operation: (at full load)

| | | | | | |
|---|---|---|---|---|---|
| Transformer voltage (R.M.S.) | | 6.9 | 5.8 | 4.6 | kV |
| **Anode current | | 0.8 | 0.9 | 0.9 | A |
| **Grid current | appr. | 0.13 | 0.15 | 0.16 | A |
| Grid resistance | appr. | 1.7 | 1.45 | 1.3 | kΩ |
| Anode input power | | 6.1 | 5.8 | 4.6 | kW |
| Grid dissipation | | 60 | 75 | 75 | W |
| Anode dissipation | | 1.6 | 1.7 | 1.6 | kW |
| Power output | | 4.5 | 4.2 | 3 | kW |
| Frequency | ≦ | 30 | 30 | 60 | Mc/s |

* Values in brackets refer to FTL 3-2/FTW 3-1
** Average values

Class C, R.F. Oscillator for Industrial Use

(Anode voltage from three-phase half-wave rectifier without filter)

Max. and typical operating conditions are the same as for Class C r.f. oscillator with filtered d.c. voltage.
Vaeff (transformer) = 0,84 Va (d.c. anode voltage).

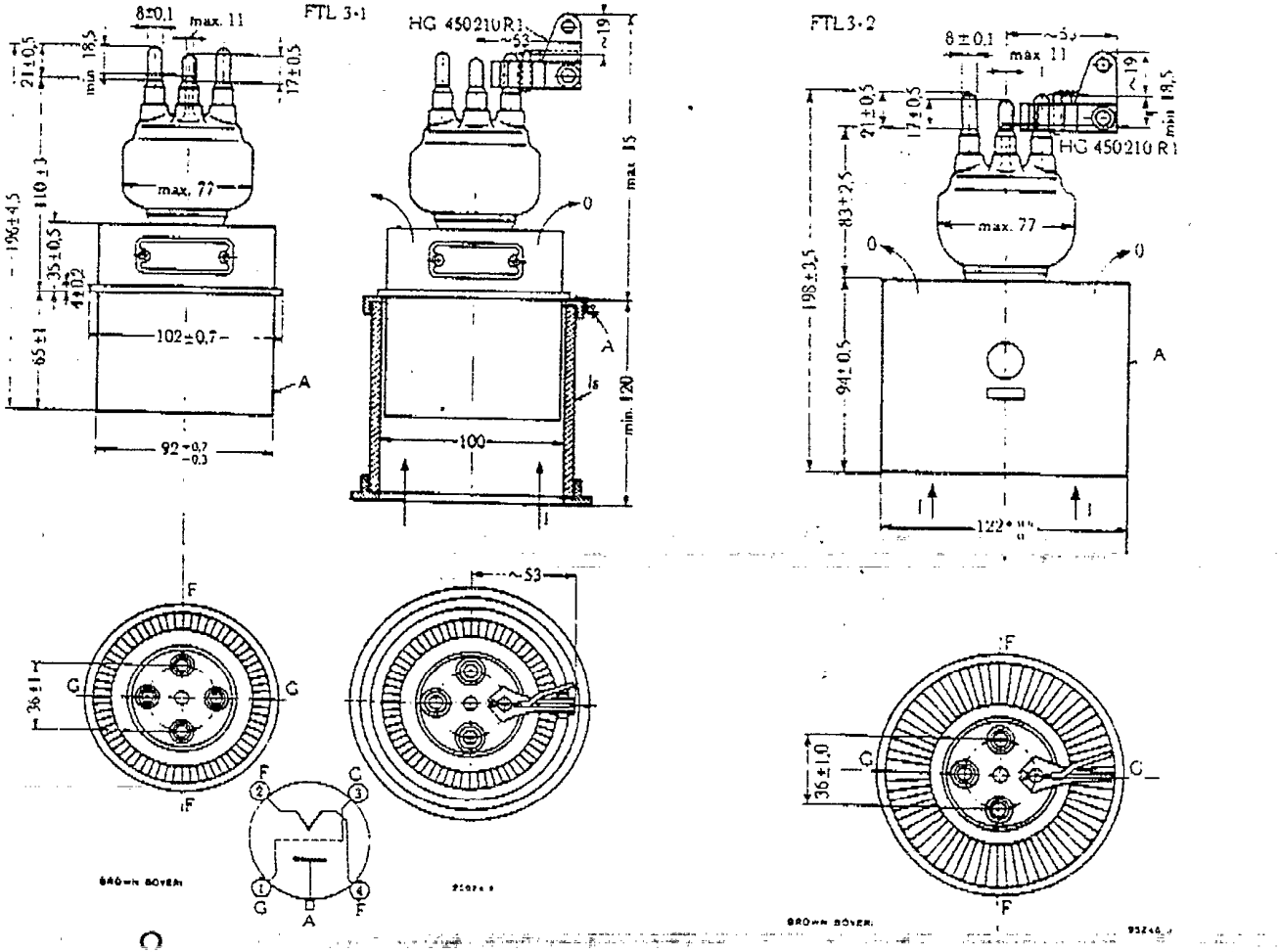
In pulse operation, used in industry for plastic welding the anode dissipation can be increased up to 6 kW and the tube is able to deliver power outputs higher than 8 kW. Data on request.

# FORCED AIRCOOLED TYPES FTL 3-1/FTL 3-2

## OPERATING INSTRUCTION

Cooling System. The tube type FTL 3-1/FTL 3-2 must be operated with its associated radiator only (Figs. 1 and 2). It should be mounted exactly vertically, the radiator downwards in a cylindrical support. In accordance with the prevailing construction and space conditions, different air guide systems can be provided. Fig. 3a and 3b show a well proved construction (Brown Boveri-6-100179 R2). The tube with its radiator is set in a metal cylinder (a) which is supported by three insulators (d). c = flexible insulating air hose, b = cleat. (All dimensions in mm). Figure 4 shows the tube used in a Brown Boveri RF generator. A = cylindrical ceramic insulator in which the tube is inserted in such a way that the heater terminals lie exactly under the relevant heater connections D. The tube is locked in the air duct cylinder A by means of a spring ring B. C = cord of insulating material between fuse holder and microswitch.

Mounting. After opening of the package the metal frame in which the tube is suspended should be carefully removed. Then the tube has to be mounted in the cylindrical support by observing that the tube is held by the radiator (C) and no by the pins (AB) or the bulb, as is shown in fig. 5. The connection of the leads to the two heater (A) and two grid pins (B) should be provided with special clamping spring connectors with cooling vanes (Brown Boveri HG 405210 R1) to which a flexible strand lead or a flexible



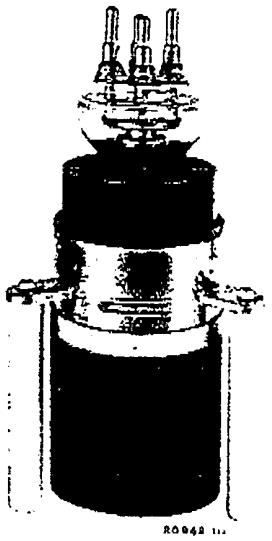


Fig. 3a

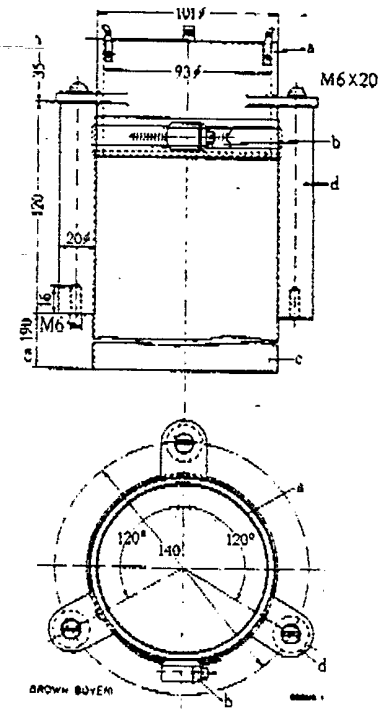



Fig. 3b

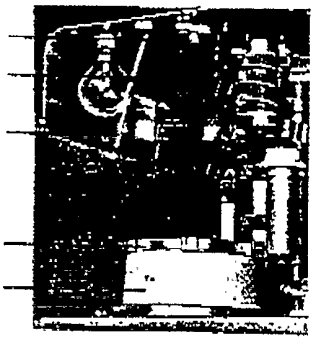


Fig. 4

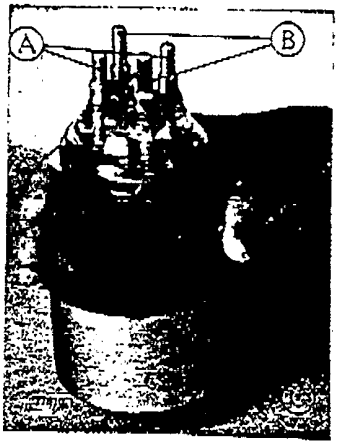



Fig. 5

Fig. 3: Air-duct system type 6 - 100179 R 2

Fig. 4: Air-duct cylinder type HG 450241 R 1

metal-strip has to be carefully connected. The installation of all wires must be made so that they will not be close or touch the glass parts. None of the terminals should be used to support circuit parts. If the tube is subjected in service to considerable vibration it is advisable to support the mounting by means of a spring suspension.

Cooling. Cooling is accomplished by passing a stream of clean air through the radiator towards the filament end. A suitable air filter is required which has to be cleaned at intervals. The temperature of the air ($T_i$) at the entrance to the radiator should not exceed 45° C. The required air flow Q ($m^3$/min) and the pressure p (mm $H_2O$) for various anode dissipations Pa (kW) is shown in Fig. 6 (FTL 3-1) and Fig. 7 (FTL 3-2). The curves have been plotted for a maximum temperature of 180° C of the anode radiator. Care should be taken that the temperature of the glass bulb means exceeds 160° C otherwise the tube must be cooled more intensely or the load has to be reduced. The temperature of the core should be measured either with a thermocouple or with temperature-sensitive paint as "Tempilac" at the end of the core, away from the incoming air.
The following temperatures must never be exceeded:

Glass bulb . . . . . 160° C
Glass base of the tube . . 160° C
Radiator core . . . . . 180° C
Inlet temperature of the air 45° C

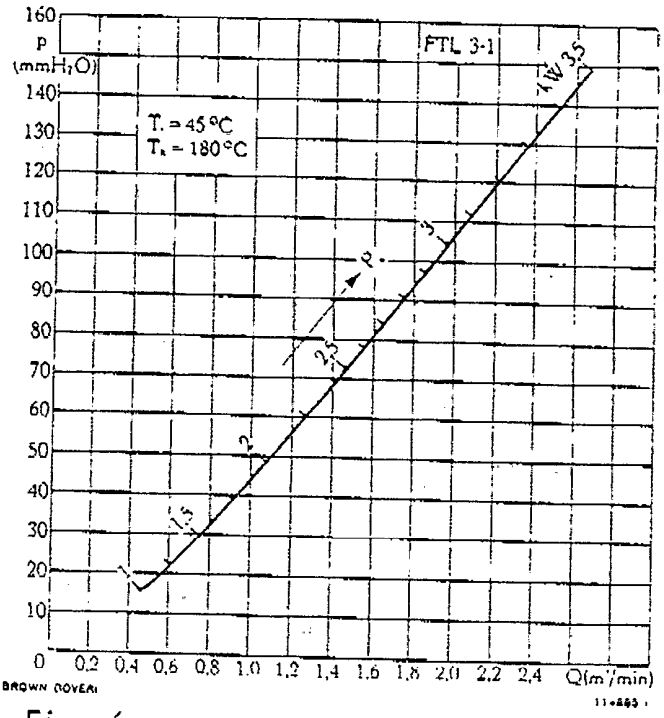


Fig. 6

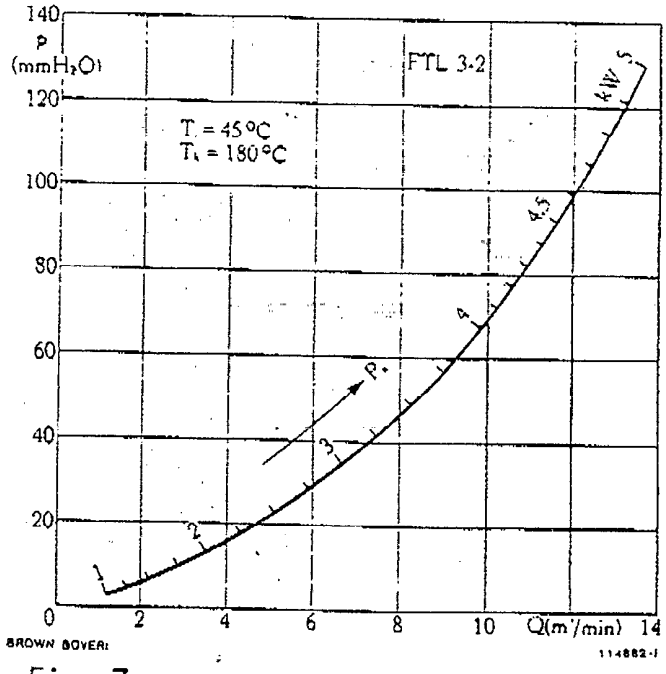


Fig. 7

Air pressure interlocks which open the power transformer primary are desirable for protecting the tube when the air flow is insufficient or ceases. The cooling should be started before or when the filament voltage is switched on. A thermal fuse holder (HG 550404 R1 with the fuse type HG 550403 R1) screwed in the tube radiator will protect the tube against overload. The fuse is over an insulating string fixed to a tension spring. When the fuse blows off owing to insufficient cooling or overload this spring will pull the release string and thus a toggle switch will remove the high voltage from the tube. Before resuming the tube operation either the cooling has to be improved or the power has te be reduced.

## OPERATING INSTRUCTIONS

Mounting. The FTW 3-1 should be mounted vertically, with its terminals directed upwards; the max. deviation from the vertical being 2 mm/m. If the tube is subjected in service to considerable vibration, it is advisable to support the mounting by means of a spring suspension. The tube is equipped with four terminals (two filament, two grid), each well distinguished by its lengths; the grid pins "G" are longer than the filament pins "F" (see figure 1.). Connection to the terminals is best accomplished by Brown Boveri clamping springs with cooling vanes (HG 450210 R1) to which flexible leads of ample cross section have to be connected carefully so that no mechanical strains be imposed on the glass-to metal seals. All connections to grid and filament must not be oxidized, and should be clean and make good electrical contact. Cleaning of the contacts should only be carried out with a soft cloth (and industrial sprits) and not with emery-paper. The installation of all wires and connections must be made so that they will not be close to or touch the glass parts, to prevent puncturing of the glass.

FTW 3-1 without and with cooling jacket W 3a

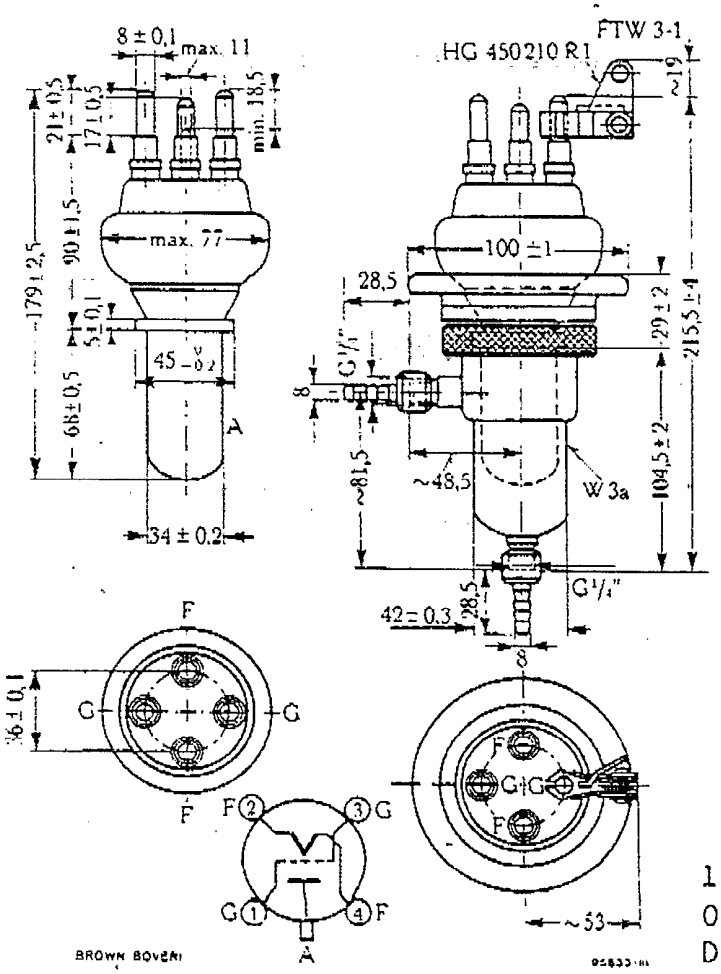



Fig. 8

New cooling jacket K 3

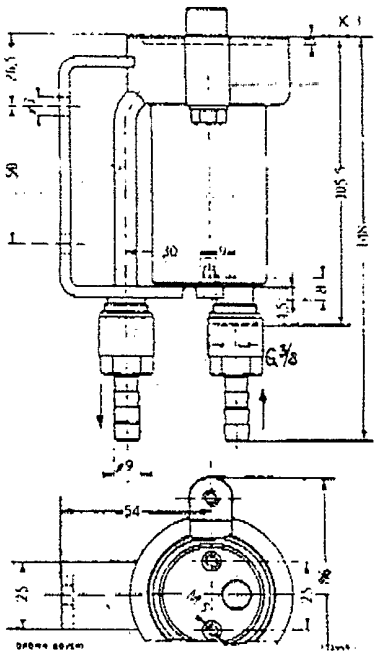



Fig. 9

1 = Water inlet
0 = Water outlet
Dimensions in mm

The cooling system. The water cooling jacket type W 3a used till now for the tube FTW 3-1 (comprising 4 demountable parts and having water inlet and outlet on different sides) has been replaced by the type K 3 (Fig. 9) of new design. It complies more satisfactorily with the requirements of the designers of r.f. generators. It can easily be fitted and mounted on a wall by means of a handle at one side. Water inlet and outlet are both on the same side at the bottom of the jacket, thus facilitating mounting in r.f. generators. Spanners for the threaded rings are no longer necessary. 2 rubber gasket rings (one for spare) are always delivered with each jacket, however, they have different dimensions as those necessary for the jacket type W 3a.
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 afterwards be rinsed with distilled water. Tubes having more than several hundreds of operating hours should be removed from their jackets for cleaning with utmost care, as their filament becomes all the more brittle as the operating hours increase. Therefore the best solution is to use distilled water.
Since the cooling jacket must be electrically insulated, both the inlet and outlet for water must be effected through sufficiently long pieces of rubber tubing or through coils of porcelain or other insulating material so that the loss current is kept to a minimum.

Cooling. 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 3.5 litres/min. for a max. anode dissipation (Pa) of 5 kW. 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 matter must in any case never exeed 30° C (70° F). The speed and pressure of the cooling water flow is also important.
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.
The tube local must be well ventilated and care should be taken that at high ambient temperature and full load the max. allowable temperature of the tube bulb of 160° C is not exceeded.
At higher frequencies (> 10 Mc/s) or at ambient temperatures higher than 70° C (160° F), measured about 5 cm above the tube head, the head should be cooled by an airstream of 0.3 $m^3$/min. blown from above to it in a distance of about 0,5 m of the same.

# GENERAL OPERATING HINTS FOR AIR- OR WATERCOOLED TUBES

Filament circuit: The filament is of thoriated tungsten and of rugged construction, with high emission capacity. Following this, the tube can be operated with filament voltages varying between + 5 % and - 10 % of the nominal value of 12 V. The voltage should be checked by a suitable voltmeter (moving iron instrument with 1 % of accuracy), connected directly to the filament terminals.

A filament starter should be used to raise the filament voltage gradually and to limit the high initial ratio of current through filament when the circuit is first closed. A starter may be either a system of time delay relays, cutting resistance out of circuit, a high reactance transformer, or a simple rheostat, so that the total filament current never exceeds, even momentarily, a value of 100 A.

In intermittent operation it is recommended that the filament voltage be reduced to about 9 V during frequent standby periods up to two hours; for longer periods the filament power should be turned off.

Grid circuit: In R.F. operation the two grid terminals should be connected in parallel, in the shortest possible way, in order to reduce undesired inductances and to prevent overheating by r.f. currents. If in A.F. operation only one grid terminal is used, both terminals must be provided with cooling vanes connectors (HG 405210 R1).

Anode circuit: Long tube life can be expected by providing these safety devices:
A time delay relay to delay the application of the anode voltage ($\frac{1}{2}$ minute) until filament has reached normal operating temperature.

An over-current relay with 1/10 second operating time should be provided, to prevent excessive anode current flow and resultant over-heating of the tube. This relay should be adjusted to open the circuit breakers in the primary of the rectifier transformer at slightly higher than rated anode current.

A protecting anode resistor of about 25 ohms connected in the anode lead of each tube will damp sudden short circuit peaks during the time required for the relay and the circuit breaker to act.
When adjustments or tuning of a circuit are made, the anode voltage should be reduced to approximately one-half of the rated value, to prevent damage of the tube and associated apparatus.

A new transmitting tube should be first initially heated for 15 minutes at rated filament voltage before application of any other voltage and only then anode voltage should be applied and gradually be brought up to normal value.

## OPERATION

Class C, Unmodulated R.F. Amplifier: In this class of service 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. If the tube is operated at the maximum rated anode voltage of 6 kV a fixed bias of at least - 200 volts should be used.

For industrial use, as oscillator e.g. in r.f. industrials 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 limits. 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.

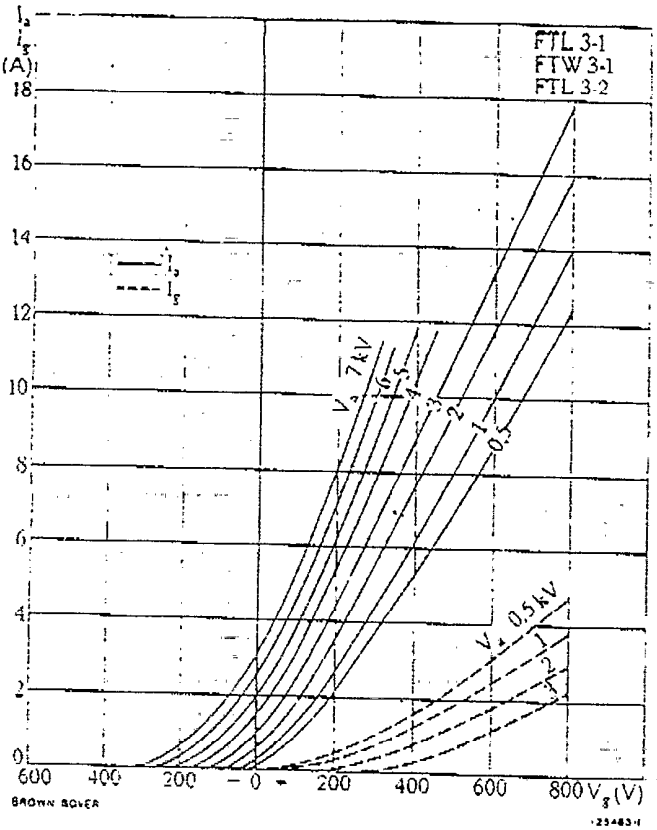
Parasitic oscillations can be suppressed by means of a resistor-coil combination made up of a non-inductive resistor of about 20 ohms, shunted by 3 turns wound right around the resistor, connected as near as possible to the grid. In some cases it may be necessary to place such a combination in the plate lead too.

A remarkable feature of the FTL 3-1/FTL 3-2 is its well designed cathode which allows to be operated with greater voltage fluctuations. Thus the filament voltage can vary within + 5 % and - 10 % of the nominal value. The typical operating ratings are based on a reasonable and sufficient power reserve preventing thus the anode and grid of the tube to be overloaded. Emission capacity which has been reduced or lost by thermal overload can often be restored by heating the tube at nominal filament voltage for about 10 min. or more without applying other voltages.

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 with advantage stored in its original packing. For transmitting tubes held in stock it is sufficient to be put into operation for about 1 hour only once after the first 6 months of stocking. They should initially be heated for 15 minutes at rated filament voltage only. If possible, during further 15 minutes half of the max. admissible anode voltage should then be applied to the tube which should then be run at full load for at least one hour.

The dimensions of the tube type FTL 3-1 are the same as those of the obsolete type ATL 2-1, which therefore can easily be replaced by the FTL 3-1 economizing of 288 W filament power in this case. The characteristics of the types FTL 3-1, FTL 3-2, FTW 3-1 are equal.

$I_a$ = Anode current
$V_a$ = Anode voltage
$I_g$ = Grid current
$V_g$ = Grid voltage
$I_{kp}$ = Peak cathode current


FTL 3-1
FTW 3-1
FTL 3-2
$I_a$ (A)
$I_a$
$I_g$
$V_a$ 7 kV
6,5
4
3
2
1
0,5
$V_a$ 0,5 kV
1
2
3
$V_g$ (V)
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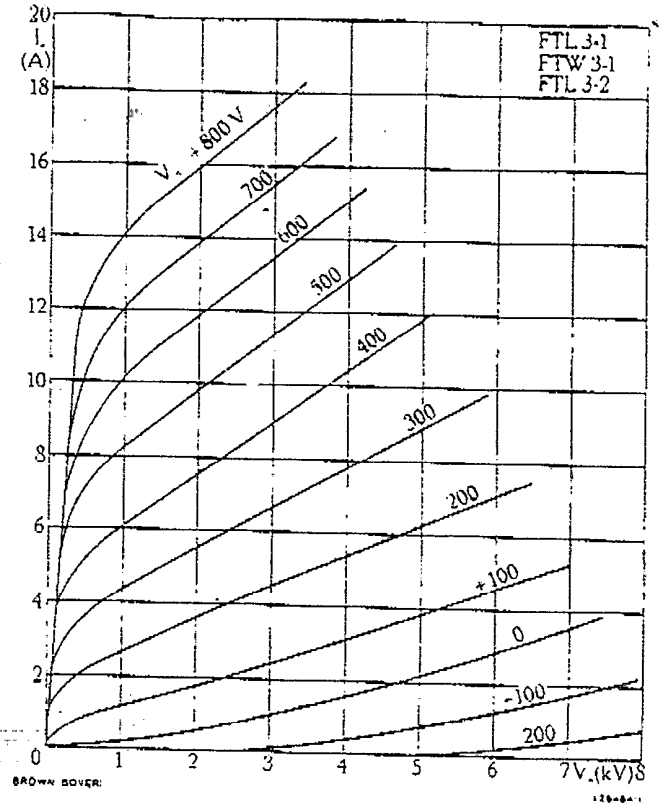
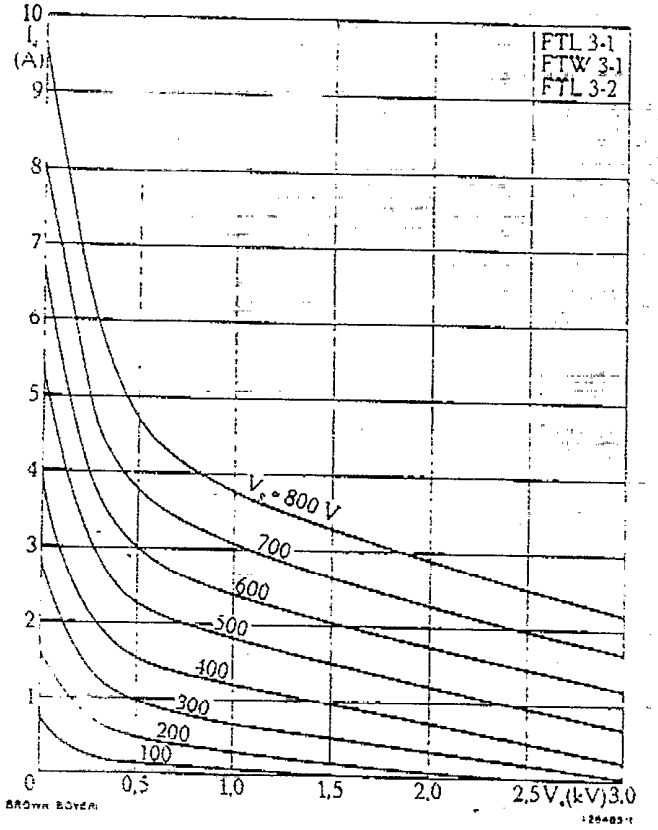
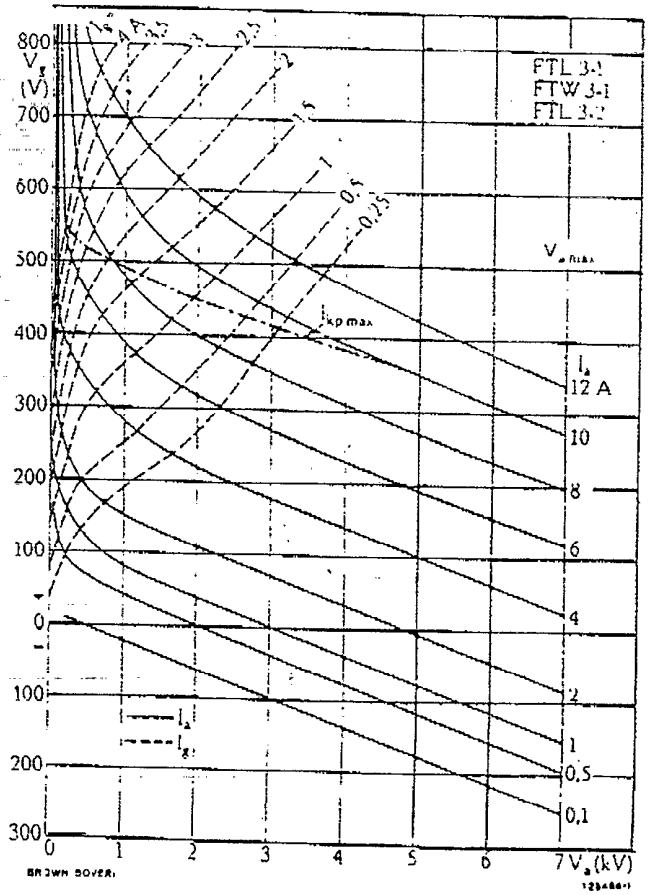

FTL 3-1
FTW 3-1
FTL 3-2
$I_a$ (A)
$V_a$ + 800 V
700
600
500
400
300
200
+ 100
0
- 100
200
$V_a$ (kV)
BROWN BOVERI


FTL 3-1
FTW 3-1
FTL 3-2
$I_a$ (A)
$V_g$ = 800 V
700
600
500
400
300
200
100
$V_a$ (kV)
BROWN BOVERI


FTL 3-1
FTW 3-1
FTL 3-2
$V_g$ (V)
2,5
2
1,5
1
0,5
0,25
$V_{a\,max}$
$I_{ap\,max}$
$I_a$
12 A
10
8
6
4
2
1
0,5
0,1
$I_a$
$I_g$
$V_a$ (kV)
BROWN BOVERI