Philips Klystrons Hamburg

Installing and Operating Klystron YK 1304

Contents

For specific Technical Data please see the current Data Sheet YK 1304

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Diagrams

Notes about this Manual

1. This manual describes the unpacking, assembly, installation, operation and tube replacement of klystron YK 1304 and its ancillary equipment.

2. When carrying out an assembly procedure for the first time, read this manual first. Also carefully read the test report which is supplied with the klystron. Refer also to product specification YK 1304.

WARNING: RADIATION DANGERS.

CAUTION: ***Klystrons can be damaged by incorrect handling. It is therefore necessary to proceed carefully and according to instructions at all times.***

RF Radiation:
RF Power may be emitted not only through the normal output coupling but also through other apertures (for example RF leaks). This RF Power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation will be increased if the tube is functioning incorrectly.

The RF radiation 1 m away from any part of the klystron at max. output power will not exceed 0.1 mW/cm^2.

X-Radiation:
Due to the high accelerating voltage, the klystron generates a high level of X-rays. Therefore the complete assembly must be shielded during operation in order to reduce the radiation to a non-dangerous level. The tube manufacturer recommends a shielding made from lead sheets at least 3 mm thick and capable of reducing the X-radiation to a safe level. Care must be taken in the construction of this shielding to avoid any holes or slots.

Compliance with the local regulations regarding radiation hazards must be confirmed by the user. If in any doubt refer to your local Philips representative or to the manufacturer:

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Installing and Operating Klystron YK 1304

1. Receiving Inspection

1.1. Equipment delivered

(a) Depending on the method of shipment to the customer, the equipment will be delivered in five wooden crates or on pallets. The delivered equipment should be:

- YK 1304	high-power klystron (may be with waveguide iris) mounted in support frame TE 1177 and on transport trolley TE 1178
-	spare 'O'-ring, Viton, 285 x 5
- TE 1158	4 off, HV socket, R3 (see note below)
- TE 1159	4 off, HV cable, length 6 m or
- TE 1160	4 off, HV cable, length 10 m (see note below)
- TE 1164B	coaxial/waveguide transition WR 1800 with 45° waveguide elbow
- TE 1165	RF window cooling-air inlet plate
- TE 1167	klystron trolley with adjustable waveguide support (carrying factory-fitted lead hielding TE 1172)
- TE 1168	water outlet collecting tube
- TE 1169	2 off, interconnecting water hose
- TE 1170	collector water cooling jacket (with three support legs TE 1170S)
- TE 1175	lifting yoke for TE 1263 and TE 1266
- TE 1176	lifting yoke for klystron YK 1304
- TE 1263	HV connection unit
- TE 1266	focusing coil unit with four separate pole-piece segments
- TE 1271	set of interconnecting cables and fittings for connections inside TE 1263
- TE 1273	accelerator anode ring
- TE 1274	two-part cathode cooling ring assembly

NOTE: *In general, a HV cable (TE 1159 or TE 1160) with an R3 plug on each end is fed into each of the four R3 sockets on the HV connection unit (TE 1263). The four R3 sockets (TE 1158) are installed in the power supply, to receive the cables to the HV connection unit (TE 1263). The four R3 dummy plugs (TE 1161) are provided for HV tests.*

(b) Packages:

Fittings (nuts, bolts, washers etc) are supplied in packages as follows:

Package	Contents	Purpose
P1	12 off bolt, M6x30 12 off washer	collector water cooling jacket (TE 1170) to flange of klystron
P2	4 off threaded rod, M10x100 12 off nut, M10 19 off washer	water outlet collecting tube (TE 1168) to frame of klystron trolley (TE 1167)
P3	4 off two-part clamp with nut and bolt 4 off sealing ring	interconnecting water hoses (TE 1169) to collector water cooling jacket (TE 1170) and water outlet collecting tube (TE 1168)
P4	3 off special shoulder screw, M12 3 off insulating bush 6 off insulating washer	collector water cooling jacket (TE 1170) to braces on frame of klystron trolley (TE 1167)
P5	not supplied (factory-fitted)	waveguide support to klystron trolley (TE 1167)
P6	6 off bolt, M5x12 6 off washer	coaxial/waveguide transition (TE 1164B) to waveguide support
P7	12 off bolt, M8x25 12 off washer	RF output window flange to coaxial/waveguide transition (TE 1164B)
P8	12 off bolt, M6x60	coaxial inner conductor
P9	12 off bolt, M5x12 12 off washer 2 off nozzle, 6x1/8", PVC 1 off square-head plug screw	RF output window cooling-air inlet (TE 1165) to coaxial/waveguide transition (TE 1164 B)
P10	2 off clamping device 2 off bolt, M6x40 2 off washer 2 off spring washer	HV connection unit (TE 1263) to focusing coil unit (TE 1266)
P11 (4 off)	4 off bolt, M5x10 2 off bolt, M5x20	R3 sockets (TE 1158) to HV connection unit (TE 1263)
P12	8 off distance tube 8 off threaded rod, M4x50 8 off nut, M4 8 off washer 8 off cap nut, M4	cathode cooling ring assembly (TE 1274) to cathode flange of klystron
P13	HV plug UG 496/U Plug SLFFD 23 C (straight) Plug SLFFC 23 C (angled)	Ion getter pump Foc-unit TE 1266 HV conn. unit TE 1263

1.2. Visual Inspection

(a) Check that the equipment delivered is in line with paragraph 1.1.

(b) Within 7 days of receipt, visually inspect all delivered equipment for signs of damage during transit. Any problems must be reported **immediately** to your local Philips representative or to the manufacturer.

1.3. Vacuum Check.

Immediately after the klystron has arrived at the customers' site a vacuum check must be carried out.

1.3.1. Test Equipment Required.

The following test equipment will be required by the customer:

(a) Ion getter pump d.c. power supply having an open circuit potential of between 3 kV and 4 kV and an internal resistance of approximately 300 kΩ. The power supply should have a built-in current meter capable of withstanding 1 mA but also capable of clearly indicating as low as 1 μA (e.g. Varian Vacion Pump Control Unit).

(b) A 10 V heater power supply capable of supplying a current of min. 10 A. The supply may be a.c. (rms) or d.c. and should have a built-in current meter.

1.3.2. Vacuum Check using the Ion Getter Pump.

Connect the d.c. supply (see clause 1.3.1. (a)) to the ion getter pump (Fig. 1) by HV cable. The plug on the ion getter pump is either Type UG 496/U (standard, supplied in package P13) or customer specific connection (e.g. Radiall Type THT 20B, optional).
Switch on the 3 to 4 kV d.c. supply and observe the ion getter pump current. It should fall (from less than 100 μA) within less than 5 minutes to a value below 1 μA. Gently knocking at the pump will sometimes help it to start if the initial current is zero.

NOTE: *If there is no apparent pump current flowing the tube is either absolutely perfect (high vacuum) or defective (down to air). In order to determine which, it is necessary to carry out another check by a filament resistance test.*

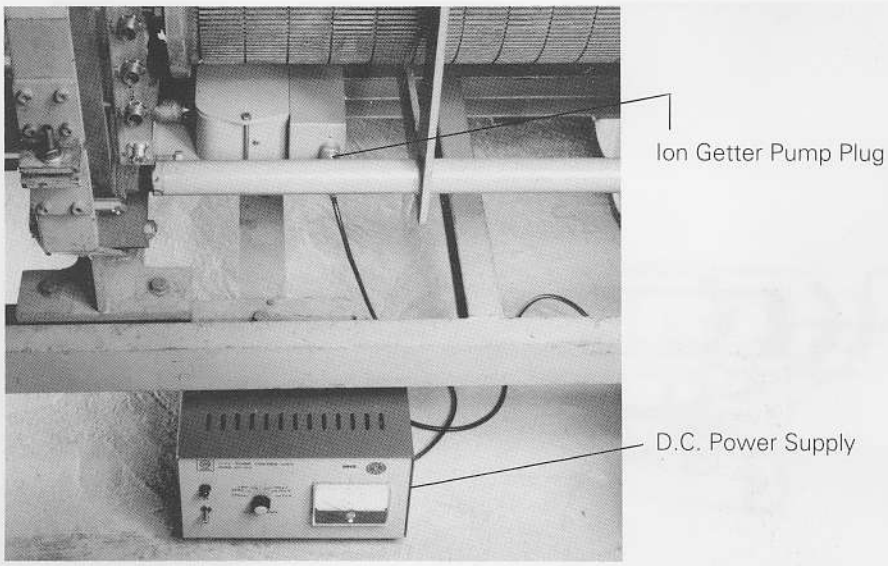


Fig. 1. Carrying out a Vacuum Check

1.3.3. Vacuum Check by Filament Resistance Test.

Connect the adjustable power supply (0 - 10 V, 10 A min, see clause 1.3.1.(b)) to the filament (Fig. 2). Increase the supply voltage gradually while keeping the current constant at 10 A. After 3 minutes read the voltage across the filament. If the voltage is > 5 V the tube has good vacuum. If the voltage is below 2.5 V the tube is likely to be defective and the tube manufacturer should be informed. (Voltages in between these values should not occur since this would lead to a non-zero pump current.)

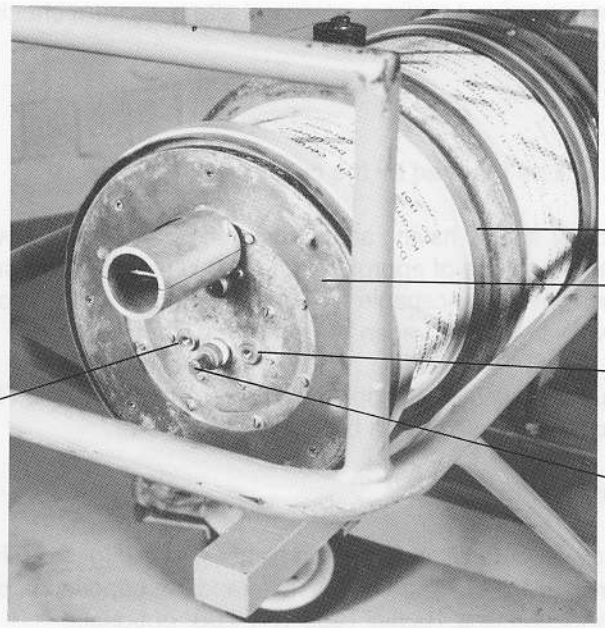


Fig. 2. Connection for Filament Resistance Test

2. Storage

(a) Normally the klystron should be stored on its transport trolley (TE 1178), see Figs. 3, 4 and 5.

(b) The storage area **must** be dry.

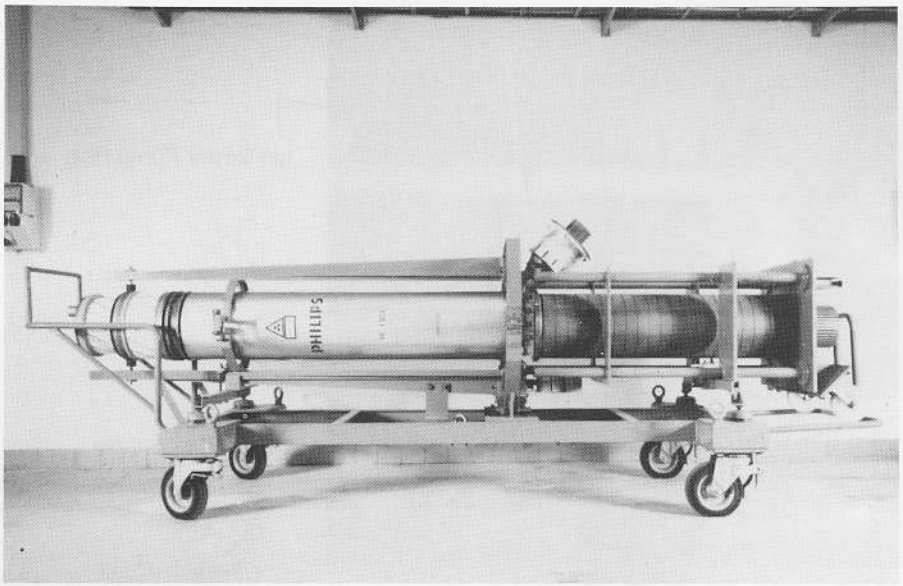


Fig. 3. Klystron on its Transport Trolley (TE 1178)

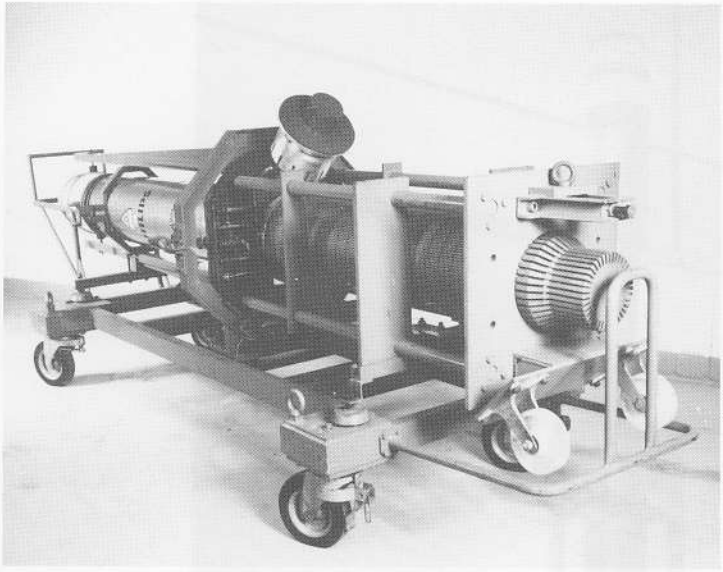


Fig. 4. View from Collector End

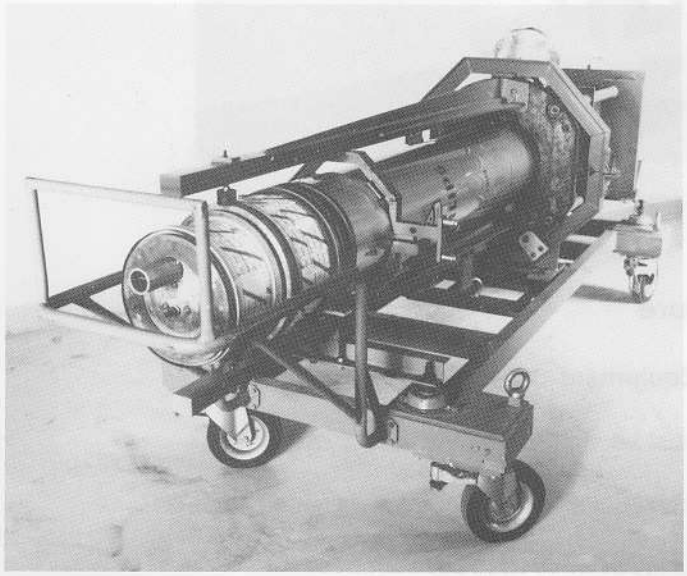


Fig. 5. View from Gun End

(c) Alternatively, the klystron can be removed from its transport trolley (TE 1168), as described in paragraph 3.3, and may lie on the floor in its supporting frame (see Fig. 11), which provides sufficient mechanical stiffness.

(d) For longer-term storage, a vertical support (Fig. 6) is recommended. Although not supplied, a drawing of this vertical support is available from the tube manufacturer.

(e) During storage, the ion getter pump must be activated by performing a vacuum check (paragraph 1.3) at least once every 3 months.

Fig. 6. Vertical Support for Long-Term Storage

3. Assembly Procedure

3.1. Customer-Supplied Equipment

The following items must be supplied by the customer:

(a) fork-lift truck (only required if equipment is delivered in crates),

(b) hoist, lifting capacity at least 1000 kg,

(c) standard tool kit,

(d) silicone grease for sealing 'O' rings and for greasing HV connection cones.

WARNING: ***The delivered equipment is extremely heavy. No attempt should be made to move it without using a hoist (or fork lift truck for crates). Two people are required throughout the assembly procedure.***

3.2. Mounting Klystron YK 1304

(a) Unpack the klystron, mounted on its transport trolley (TE 1178), see Figs. 3, 4 and 5.

(b) Remove the yellow transport clamps from collector end and gun end (2 nuts and washers securing each clamp.

(c) Remove the nut and washer (Fig. 7) and open the fixing clamp around the support flange. Move clamp away from body.

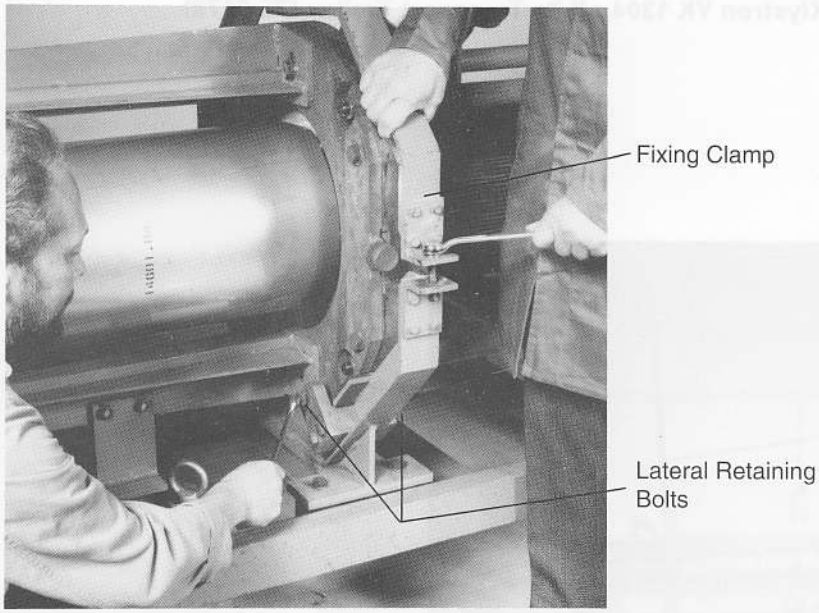


Fig 7. Releasing the Klystron Fixings

(d) Loosen the top (yellow), lateral retaining bolt (Fig. 7), one on each side of the support flange.

(e) Position the klystron on its transport trolley (TE 1178) beneath the (customer-supplied) 1000 kg hoist.

(f) Unpack the lifting yoke (TE 1176) and hook it onto the hoist. Attach the lifting yoke (TE 1176) to the two bolts (Fig. 8) on the support flange of the klystron and secure with the two safety pins or cover plates.

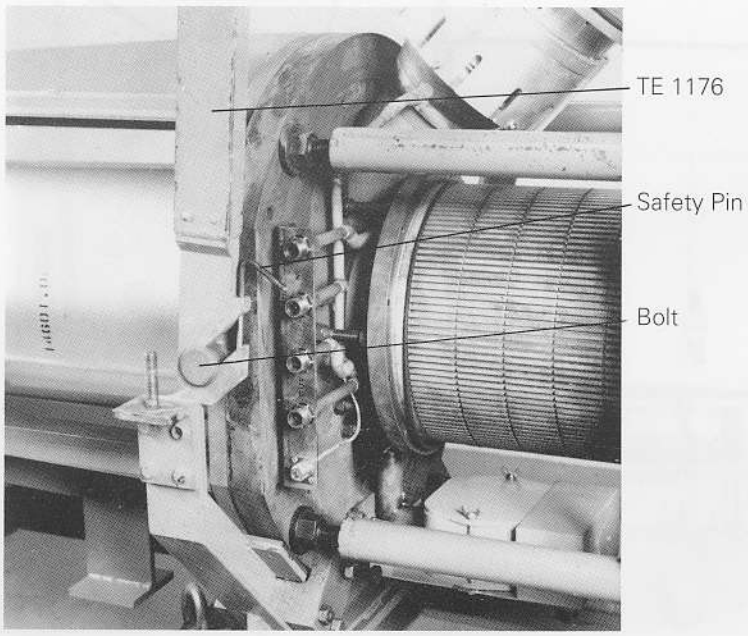


Fig. 8. Securing Lifting Yoke (TE 1176) to Klystron

(g) Attach the wire hawser (part of lifting yoke TE 1176) between the hoist and the collector supporting frame (Fig. 9).

3.3. Hoisting Klystron YK 1304 off its Transport Trolley (TE 1178)

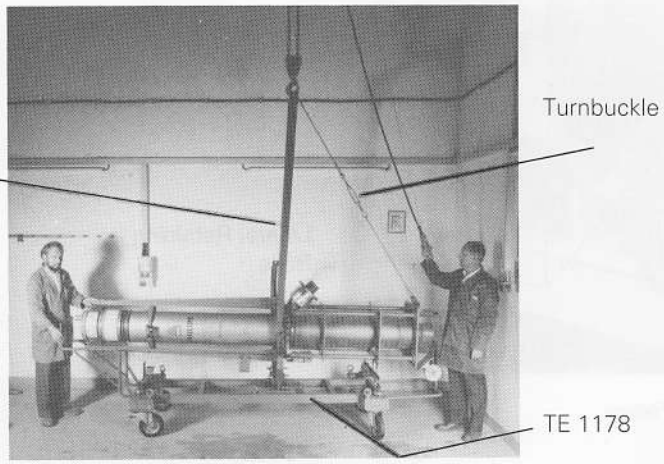


Fig. 9. Preparing to Hoist the Klystron

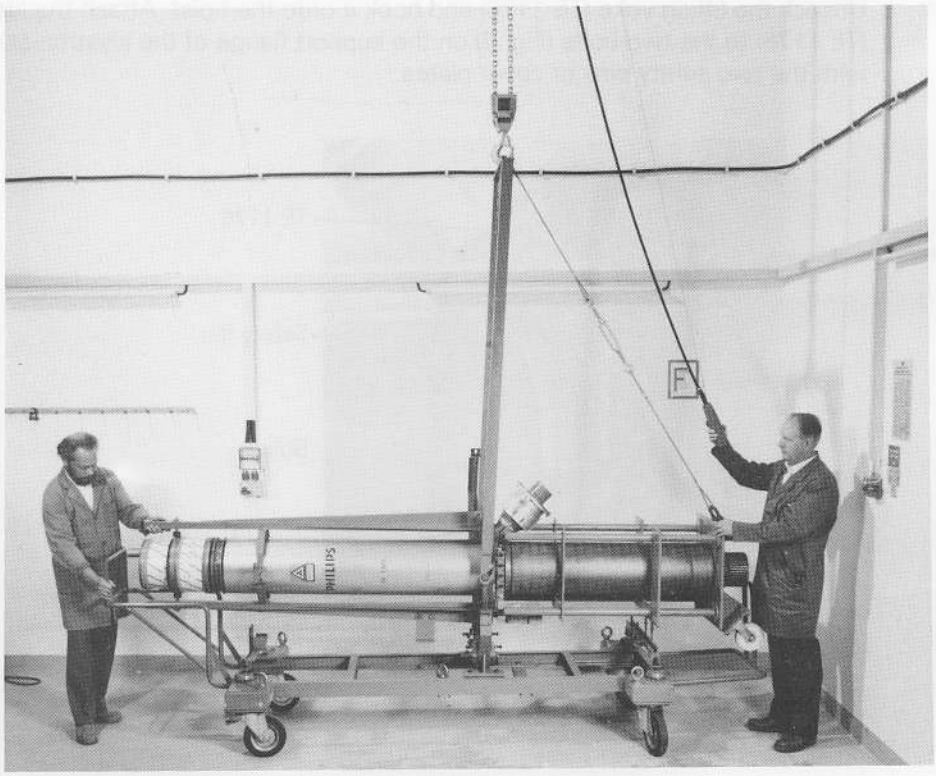


Fig. 10. Hoisting the Klystron off its Transport Trolley (TE 1178)

CAUTION: ***Two people are required at all times when hoisting the klystron. Take particular care at the gun end.***

(a) Very carefully hoist the klystron a few millimetres and observe that it lifts simultaneously from both support points of the transport trolley (TE 1178). If necessary, adjust the turnbuckle (Fig. 9) on the wire hawser to ensure that the klystron hoists exactly parallel with the ground.

(b) When completely satisfied with parallelism and balance, hoist the klystron (Fig. 10) until the transport trolley (TE 1178) can be removed.

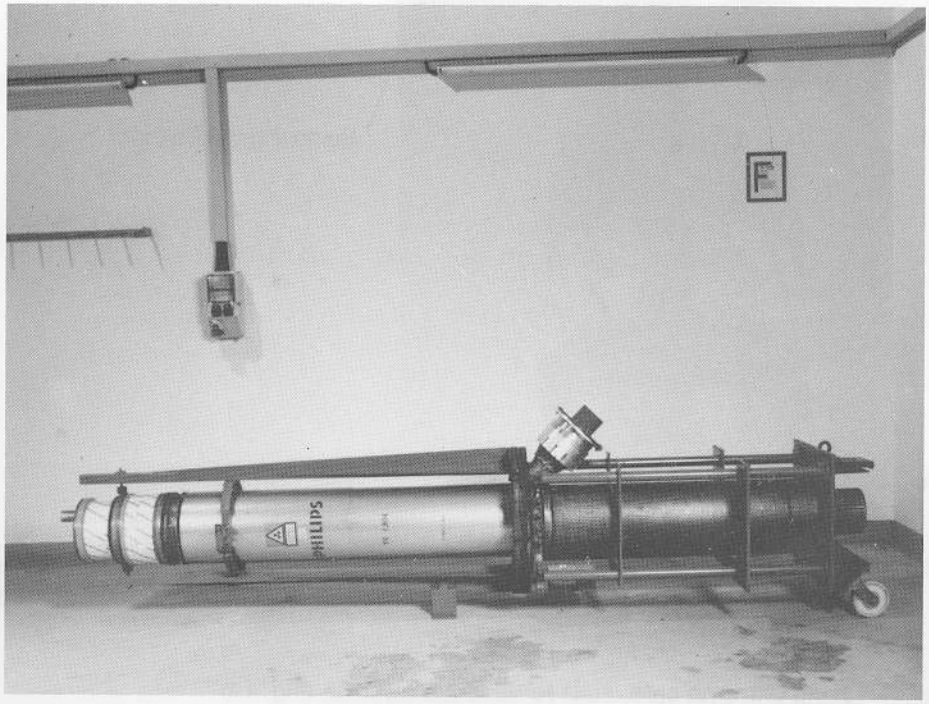


Fig. 11. Klystron Laying on Floor

(c) Remove the transport trolley (TE 1178).

(d) Carefully lower the klystron to the floor (Fig. 11). Remove and discard the wire hawser.

(e) If required, release the lifting yoke (TE 1176) from the hoist.

3.4. Raising the Klystron to its Vertikal Position

CAUTION: *Two people are required at all times when raising the klystron. This is a very delicate operation. During lifting, the klystron pivots on wheels and its changing centre of gravity can cause run-away. Raise the klystron slowly, and support it at all times.*

(a) Before raising the klystron, remove the upper bolt of each pair of bolts (Fig. 12) on either side of the body support clamp. This allows free hoisting to the vertical position.

Fig. 12. Removing Two Bolts to Allow Easy Hoisting

(b) Refit the lifting yoke (TE 1176) to the hoist, ensuring that the lifting yoke is fitted to the two bolts (see Fig. 8) on the support flange of the klystron, and secured with the two safety pinsor cover plates.

(c) Taking extreme care, start to raise the klystron (Fig. 13).

Fig. 13. Raising the Klystron

(d) Support it carefully until the klystron reaches the vertical position (Fig. 14), resting on its wheels and support.

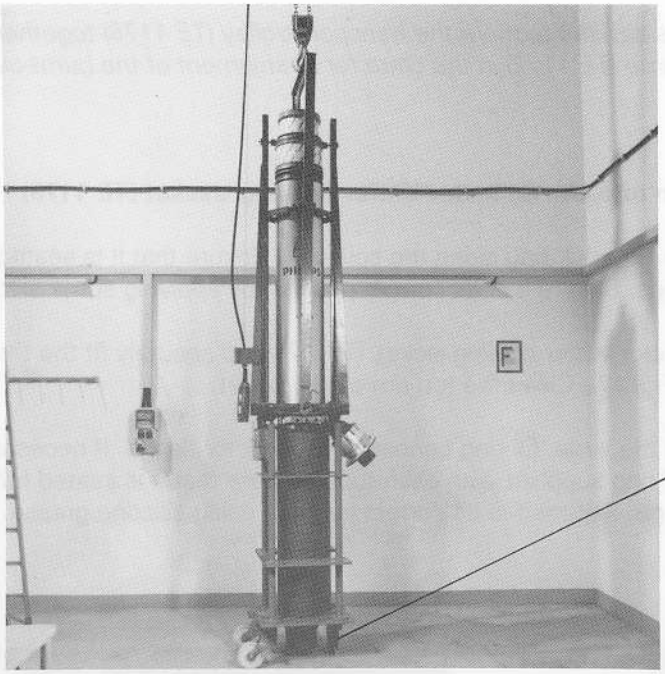


Fig. 14. The Klystron Raised to its Vertical Position

(e) Refit the two bolts on either side of the body support clamp (removed in paragraph 3.4. (a)). These bolts sustain the vertical position of the klystron while lifting.

3.5. Removing the Klystron from its Support Frame (TE 1177)

(a) Remove the four nuts (Fig. 15) from within the cut-outs of the klystron support flange.

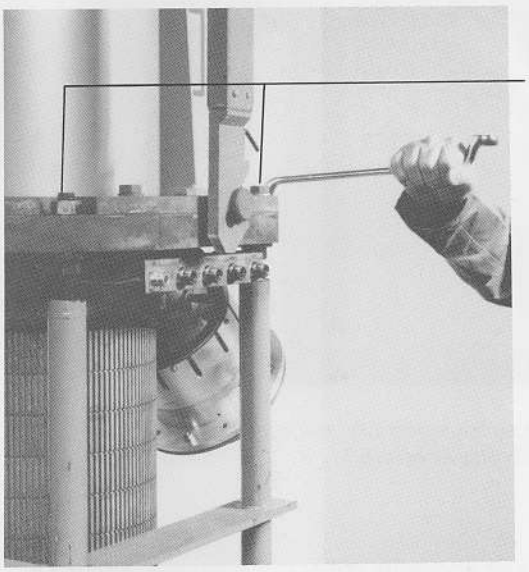


Fig. 15. Removing the Support Frame Securing Nuts

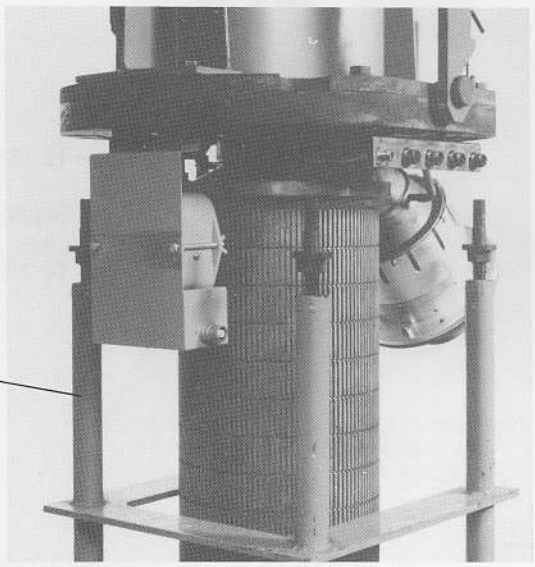


Fig. 16. Hoisting the Klystron out of its Support Frame (TE 1177)

(b) Hoist the klystron vertically out of its support frame (TE 1176) (Fig. 16).

(c) Raise the klystron fully out of its support frame, remove the support frame, refit the four securing nuts to the frame.

(d) Store the support frame (TE 1177).

NOTE: *The customer is advised to store the transport trolley (TE 1178) together with the parts of the support frame (TE 1177) in the crate for re-shipment of the burnt-out tube.*

3.6. Lowering the Klystron into the Collector Water Cooling Jacket (TE 1170)

(a) Carefully slip the large 'O' ring along the collector. Ensure that it is seated fully against the collector flange. Secure it in its correct position by applying some silicone grease.

(b) Unpack the collector water cooling jacket TE 1170 and securely fit the three support legs TE 1170S (Fig. 17). Clean the top rim of the jacket.

(d) Carefully inspect the large 'O' ring beneath the collector flange. If necessary, replace it by the new 'O' ring supplied with each tube. Ensure that it is seated fully against the collector flange. Secure it in its correct position using silicone grease.

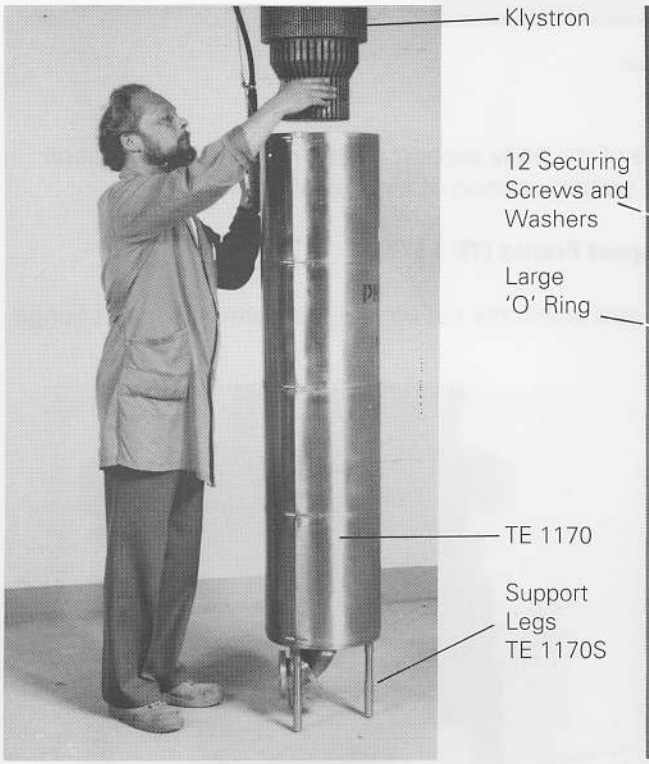


Fig. 17. Preparing to Lower the Klystron into its Collector Water Cooling Jacket TE 1170

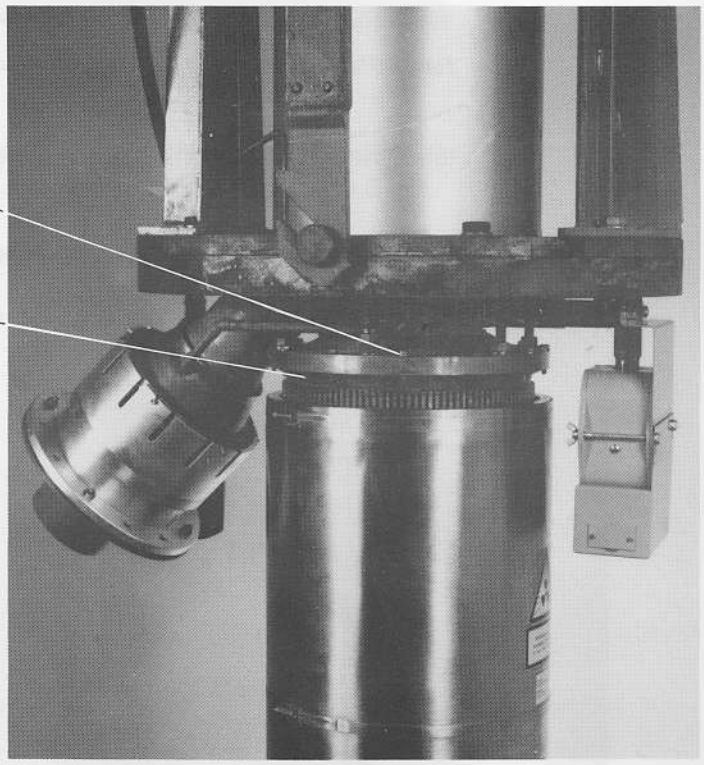


Fig. 18. Klystron almost fully inside the Collector Water Cooling Jacket (TE 1170)

(e) Very carefully lower the klystron until it is just above its collector water cooling jacket (TE 1170). Adjust the position of the jacket as necessary and very slowly lower the klystron into the collector water cooling jacket. Stop before it is fully in (Fig. 18).

(f) Orient the collector water cooling jacket (TE 1170) to its normal orientation (so that the water inlet flange is beneath the RF output window of the klystron).

NOTE: *The orientation can be changed according to customer-requirements.*

(g) Check the correct seating of the large 'O'ring, hard up against the collector flange.

(h) Open package P1 (paragraph 1.1.(b)) and fit one M6x30 securing screw with washer (Fig. 18) into each of the twelve holes in the collector flange.

(i) Lower the klystron carefully until it is about 1 mm above the collector water cooling jacket (TE 1170).

(j) Rotate the jacket a little as required and hand-tighten each of the twelve screws into its mating tapped hole in the collector water cooling jacket (TE 1170).

(k) Carefully lower the klystron until it just touches the collector water cooling jacket (TE 1170). Tighten all twelve screws evenly. Check that orientation is correct.

(l) Hoist the klystron and its jacket. Unscrew and discard the three support legs (TE 1170S).

3.7. Preparing the Klystron Trolley (TE 1167)

(a) Unpack the trolley (TE 1167), with factory-fitted lead shielding plates (TE 1172) (Fig. 19) and two angled plates, see Fig. 48).

Fig. 19. Trolley (TE 1167) with Factory-Fitted Lead Shielding Plates (view from rear)

NOTE: *During the following text, the rear of the trolley (TE 1167) is defined as the part with the opening, housing the RF output of the klystron.*

(b) Remove the three lead shielding plates (TE 1172) by removing the knurled screws and washers. Do not remove the right-hand plate.

WARNING: ***The lead shielding plates are extremely heavy. Two persons are necessary to handle these plates.***

(c) Position the trolley in a suitable position on flat ground beneath the hoisted klystron. Secure the trolley by screwing down its stands. Use a spirit level to ensure that the hoist is perfectly leveled.

(d) Unpack the water outlet collecting tube (TE 1168) and fasten it to the trolley (TE 1167) using the threaded rods, nuts and washers from package P2 (paragraph 1.1. (b)), as shown in Fig. 20. Ensure that the two connecting flanges point to the left.

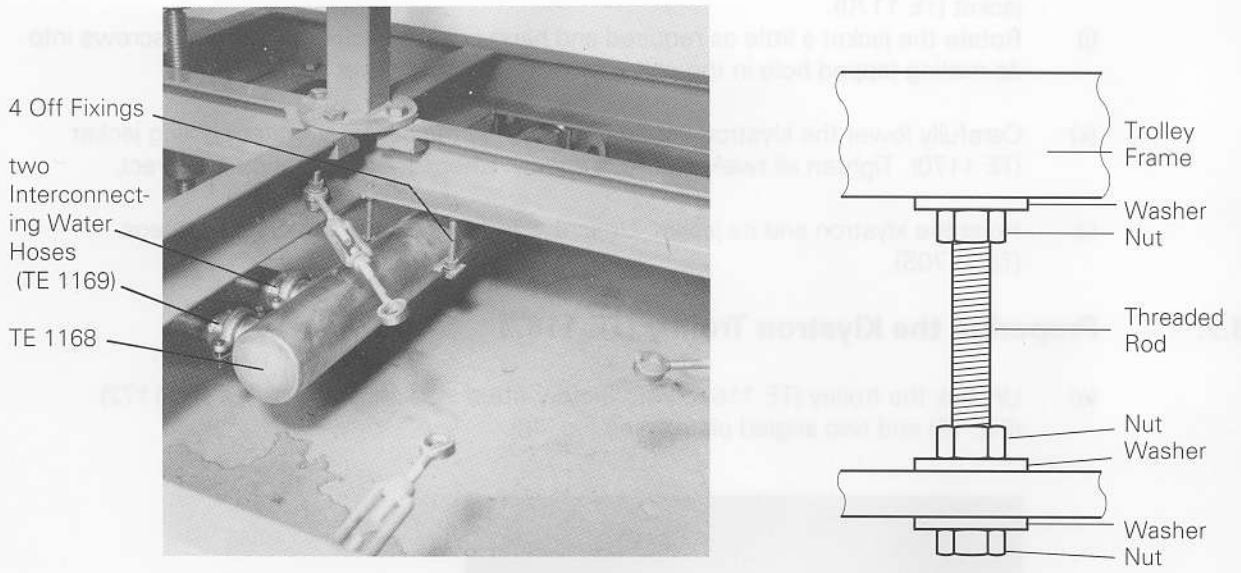


Fig. 20. View from Front of Trolley (TE 1167)

(d) Unpack the two interconnecting water hoses (TE 1169) and their fastenings from package P3 (paragraph 1.1. (b)). Use two of the two-part clamps (with nuts and bolts) and two of the sealing rings, and fasten one end of each interconnecting water hose (TE 1169) to the two connecting flanges (see Fig. 27) on the water outlet collecting tube (TE 1168) as follows:

- apply some silicone grease to the sealing rings
- clean the groove in each flange
- position the sealing rings carefully in the grooves
- fit the two-part clamps but leave loose at this stage.

3.8. Lowering the Klystron into the Trolley (TE 1167)

(a) Place trolley (TE 1167) beneath the klystron, such that the coaxial RF output of the klystron points towards the rear of the trolley.

(b) Adjust the height of the four support studs to exactly 70 mm (Fig. 21).

(c) Carefully lower the klystron (Fig. 22) into the trolley (TE 1167), ensuring that the support studs correctly align with the holes in the support flange of the klystron. Retain the weight on the lifting yoke.

(d) If necessary, slightly adjust the support studs (Fig. 22) until the collector water cooling jacket (TE 1170) is centred in the trolley.

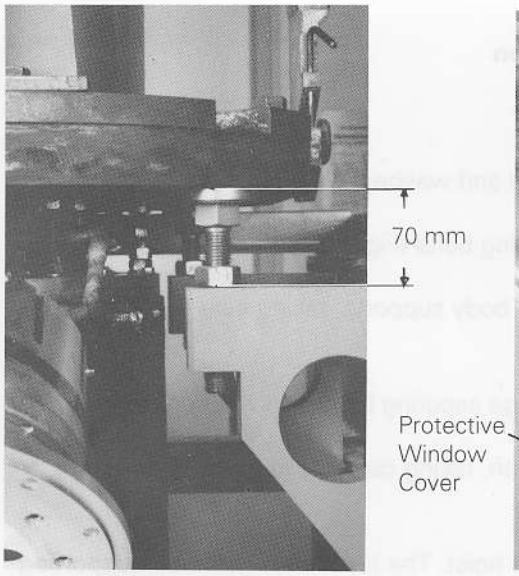


Fig.21. Height of Support Studs

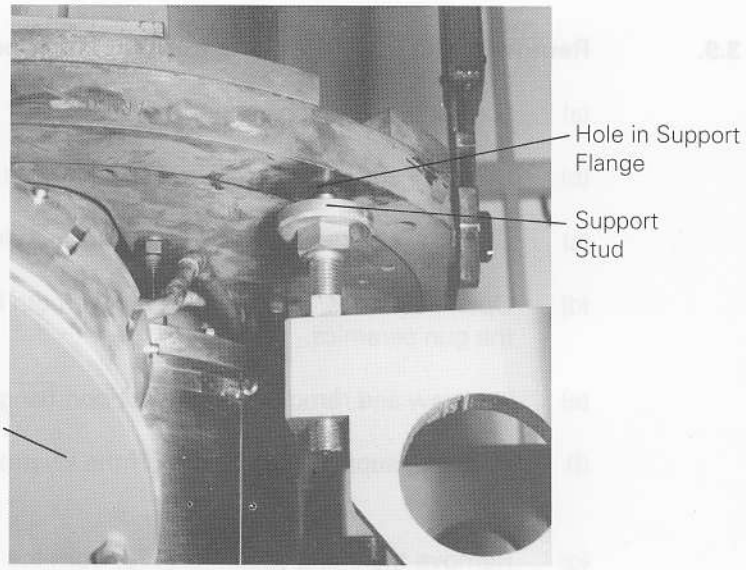


Fig. 22. Aligning Klystron with Trolley (TE 1167)

(e) If necessary, slightly rotate the support flange of the klystron (holes are slightly larger-diameter than support studs) until the RF output window of the klystron is parallel with the waveguide support (Fig. 23). This is a coarse adjustment; a fine adjustment is possible later.

(f) Lower the hoist slightly, so that the klystron sits unter its own weight in the trolley (TE 1167).

(g) If required (customer-connection), fit the RF window air temperature sensor fixture (Fig. 24)

NOTE: *Protetive window cover has been removed for illustration purpose.*

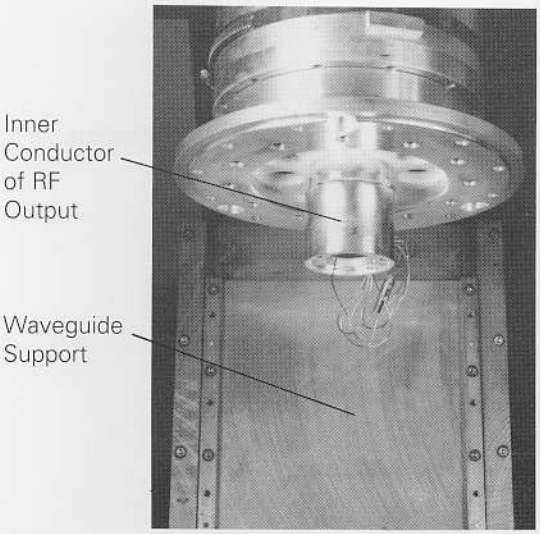


Fig. 23. Coarse Adjustment for Parallelism

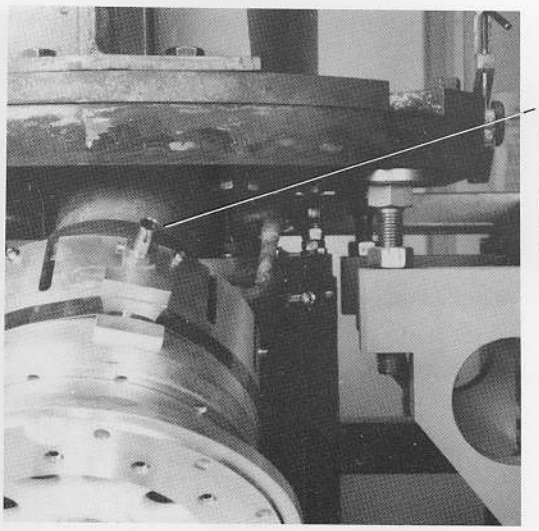


Fig. 24. RF Window Outlet Air Temperature Sensor (customer-connection)

3.9. Removing the Body Supports from the Klystron

(a) Slacken the two top supports (Fig. 25).

(b) Unscrew and remove the four bottom bolts and washers (Fig. 26).

(c) Unscrew and remove the four clamp securing bolts (Fig. 25).

(d) Open the clamp and carefully remove both body supports, taking care not to damage the gun ceramics.

(e) Unscrew and remove the four support flange securing bolts and washers (Fig. 26).

(f) Hoist the support flange right off the klystron, taking care not to damage the gun ceramics.

(g) Remove the lifting yoke (TE 1176) from the hoist. The klystron is now self-supporting in the trolley.

Fig. 25. Removing the Body Supports (1)

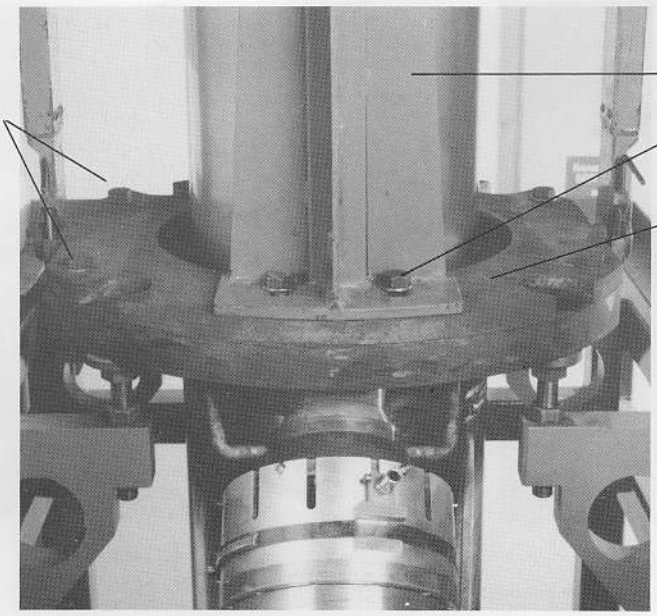


Fig. 26. Removing the Body Supports (2)

3.10. Trolley Connections

(a) Attach the free ends of the factory-fitted braces (Fig. 27) to the bottom of the collector, using the three special shoulder screws, insulating bushes and insulating washers from package P4 (paragraph 1.1.(b)).

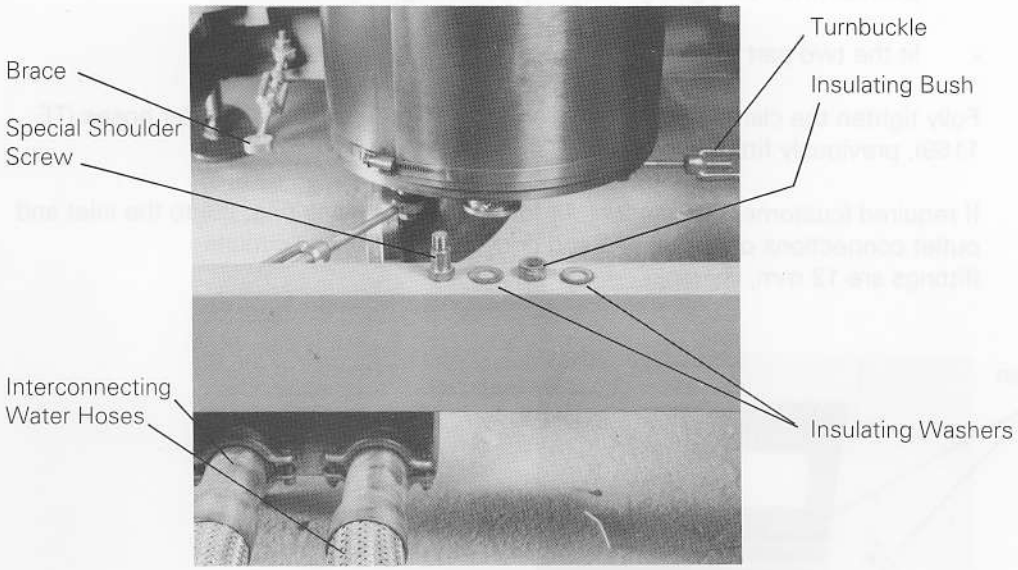


Fig. 27. View from Left Showing Attachment of Braces

NOTES:

1. ***The front brace is shorter than the other two.***
2. ***Do not apply undue force to the collector via the braces.***
3. ***Adjust the length of each brace as necessary by adjusting its turnbuckle.***

(b) Connect the free ends of the two interconnecting water hoses (TE 1169) to the collector water-cooling jacket (TE 1170) as follows (Fig. 28):

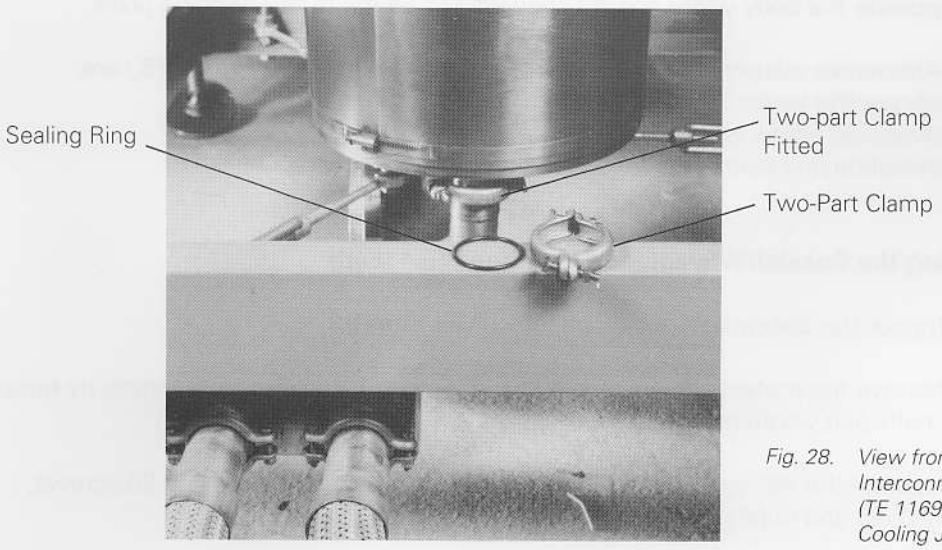


Fig. 28. View from Left Showing Fitting of Interconnecting Water Hoses (TE 1169) to Collector Water-Cooling Jacket (TE 1170)

- use two of the two-part clamps (with nuts and bolts) and two of the sealing rings from package P3 (paragraph 1.1.(b)).
- apply some silicone grease to the sealing rings.
- clean the groove in each flange.
- position the sealing rings carefully into the grooves.
- lit the two-part clamps and tighten.

(c) Fully tighten the clamps at the other end of the interconnecting water hoses (TE 1169), previously fitted in paragraph 3.7.(e).

(d) If required (customer-connection), fit four extension pipes (Fig. 29) to the inlet and outlet connections of the body 1 and body 2 water cooling circuits (fittings are 12 mm, Gyrolok).

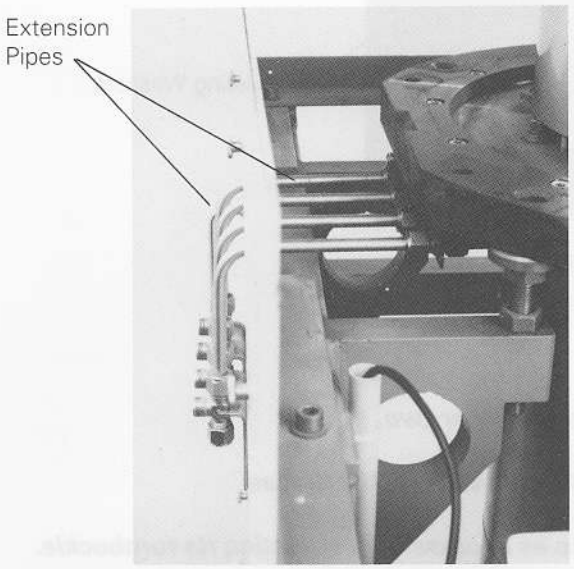


Fig. 29. Fitting the Extension Pipes (customer-connection)

(e) Connect an earthing cable from the threaded stud provided on the collector flange, opposite the body water cooling connections, to the trolley earthing point.

NOTE: *Alternative customer-connected earthing points (see paragraph 3.15.) are:*
- collector cooling water inlet (see Fig. 47)
- 45° waveguide elbow (see Fig. 46)
- HV connection unit (see Fig. 41).

3.11. Mounting the Coaxial/Waveguide Transition (TE 1164B)

(a) Unpack the coaxial/waveguide transition (TE 1164B).

(b) Remove the protective cover from the RF output window of the klystron by removing 4 bolts and washers.

(c) Separate the 45° waveguide elbow from the transition by removing 30 screws, washers and nuts.

(d) Fit the transition onto the slide of the waveguide support, using the 6 bolts and washers from package P6.

CAUTIONS:

1. ***The mounting and alignment procedure is a very delicate operation. It must be carried out carefully and methodically to avoid damaging the equipment.***

2. ***Take care not to touch the inner conductor of the RF output window.***

3. ***At all times the inner flange of the transition must be loose and free to move.***

4. ***Precise adjustments for lateral movements, height, angle and parallelism are vital for successful mounting.***

(e) Carefully study Figs. 30, 31 and 32, which show the transition mounting positions and adjustments.

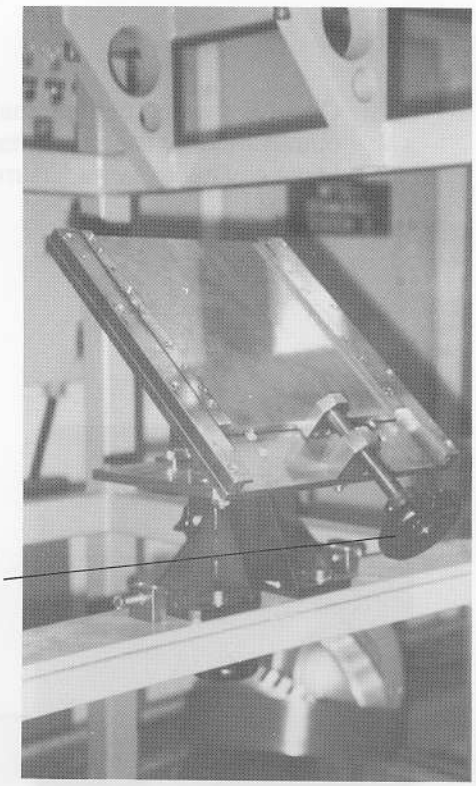
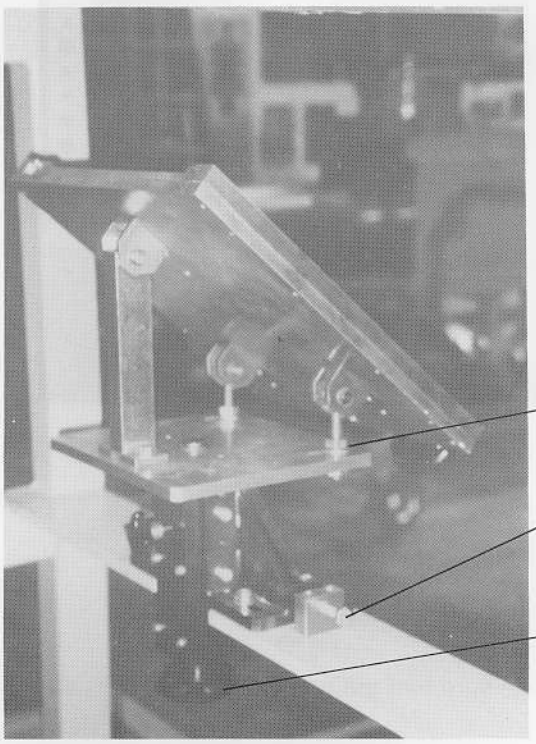


Fig. 31. Waveguide Adjustments (2)

Fig. 30. Waveguide Adjustments (1)



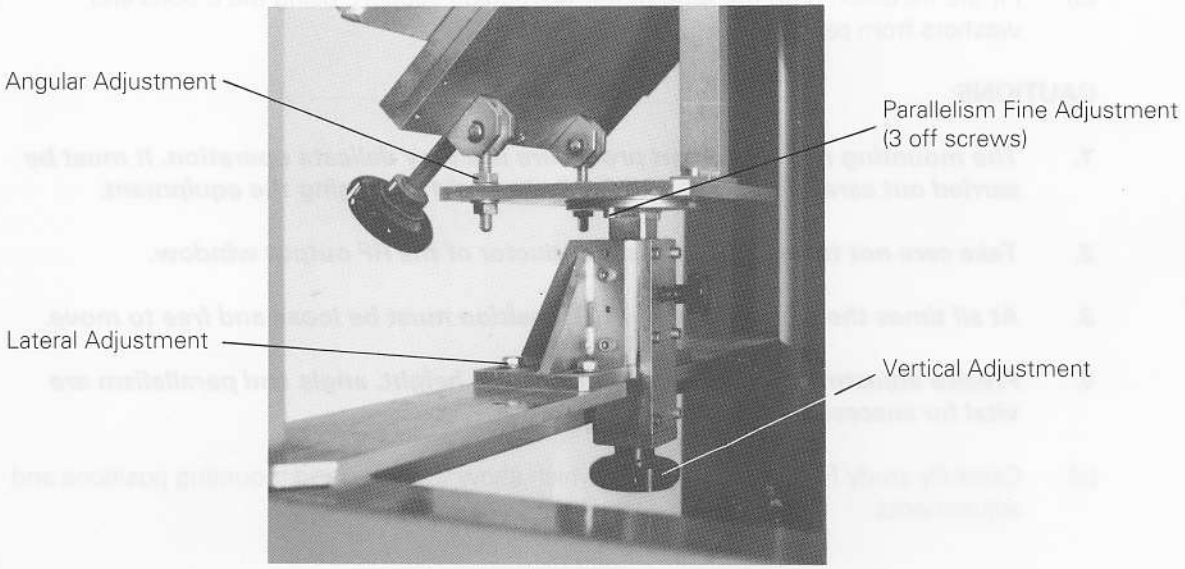


Fig. 32. Waveguide Adjustments (3)

(f) Observe the rear of the transition, particularly the parallel alignment (Fig. 33) of the RF output window flange and its mating flange on the transition.
Make any necessary adjustments, observing the CAUTIONS, until these two parts are parallel.

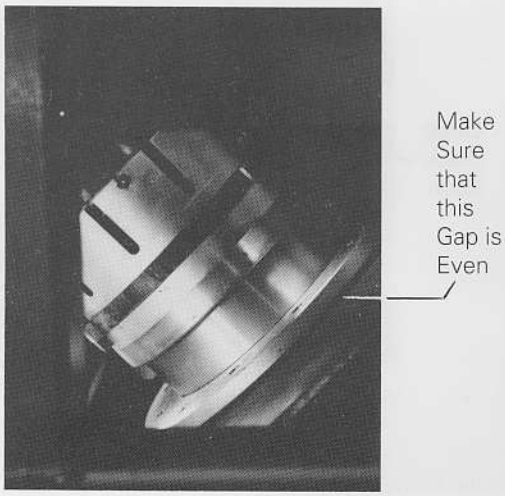


Fig. 33. Parallel Alignment of the RF Output Window Flange and the Transition.

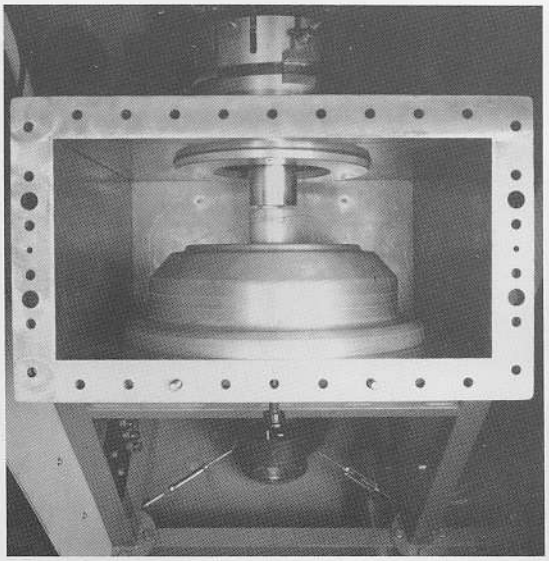


Fig. 34. View Inside the Transition

(g) Look inside the transition (Fig. 34) and make sure that the two inner conductors are aligned.

(h) Remembering the cautions, check front and rear alignment while gradually turning (clockwise) the large black knob on the waveguide support until the gap between the RF output window and the transition is almost closed (but still parallel) and the two inner conductors are almost touching (and perfectly in line).

(j) If necessary, make any fine adjustments, particularly for parallelism (Fig. 32) until you are sure that the alignments are correct.

(k) Before finally closing the gap, check that the holes are aligned for the six bolts which secure the transition to the waveguide support.

(l) Finally, before closing the gap, check the underside of the transition (Fig. 35) and ensure that the twelve holes in the flange coincide with the tapped holes in the inner conductor. If not, loosen the twelve Alleen screws and rotate the flange until the holes align. Tighten the twelve Allen screws and recheck the alignment

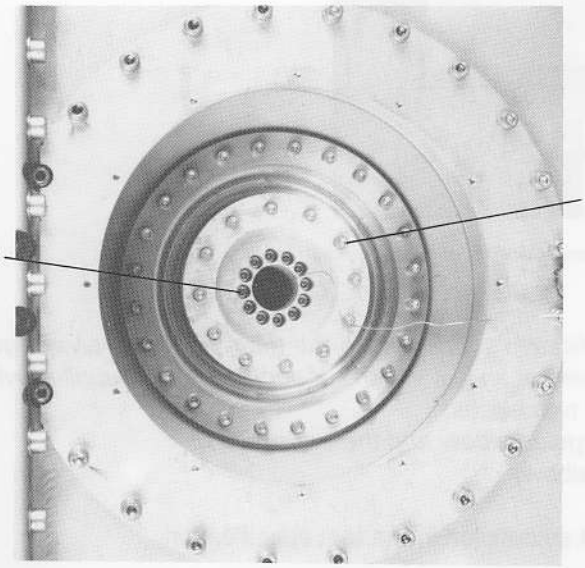


Fig. 35. View of Underside of Transition (TE 1164B)

(m) If all alignments are correct, finally close the gap by turning (clockwise) the large black knob.

(n) Secure the RF output window flange to the coaxial/waveguide transition (TE 1164B), using the 12 bolts and washers from package P7 (paragraph 1.1.(b)), with the bolts inserted from the rear.

(p) Secure the coaxial inner conductor (Fig. 35), using the 12 bolts from package P8 (paragraph 1.1.(b)). Apply a torque of 5 Nm.

(q) Finally, check that all adjustment fittings are fully tightened. Slacken the large black knob slightly.

(r) Attach the RF output window cooling air inlet plate (TE 1165) to the coaxial/waveguide transition (TE 1164B) (Fig. 36), using the 12 bolts and washers from package P9 (paragraph 1.1.(b)).

NOTE: *The version shown in Fig. 36 has a customer-connection for air inlet temperature measurement.*

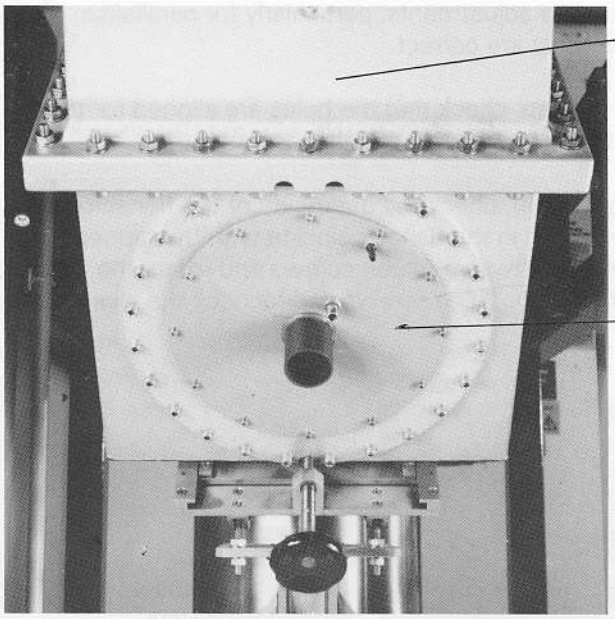


Fig. 36. Attaching the RF Output Window Cooling Air Inlet (TE 1165)

NOTE: *Refer to the test specification supplied with the tube. Some tube/waveguide configurations require the fitment of an iris, which – if applicable – is supplied with the tube. This iris can be fitted in one of two places:*
- either between the 45° waveguide elbow and the transition, or
- in top of the 45° waveguide elbow.

(s) If an iris is provided, fit it as detailed in the test specification.

(t) Refit the 45° waveguide elbow (see Fig. 38) to the transition, using the 30 screws, washers and nuts, previously removed in paragraph 3.11.(c), (screws inside).

NOTE: *To prevent foreign material falling into the 45° waveguide elbow, it is advisable to cover it with the plate supplied.*

3.12. Mounting the Focusing Coil Unit (TE 1266)

(a) Unpack the focusing coil unit (TE 1266) and remove any transport securing parts from the coils. Make sure that the four pole-piece segments are removed. Ensure that the four eye-bolts on top of the unit are tightened. Remove any dust from the contact areas.

(b) Unpack lifting yoke (TE 1175). Attach it to the hoist and attach its four shackles to the four eye-bolts on top of the focusing coil unit (TE 1266).

(c) Lift the focusing coil unit (TE 1266) about 1 metre off the floor, and remove its two undercarriages by unscrewing the four nuts on its bottom plate.

(d) Hoist the focusing coil unit (TE 1266) immediately above the klystron (Fig. 37).

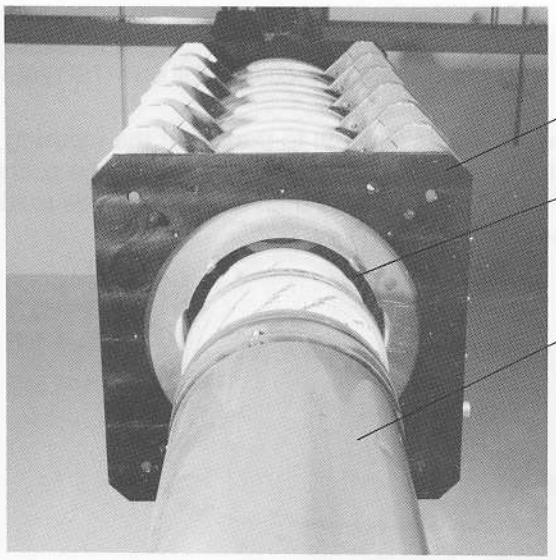


Fig. 37. View from the Ground showing Focusing Coil Unit (TE 1266) above Klystron

CAUTION: ***Lowering the focusing coil unit (TE 1266) onto the klystron is a very delicate operation which should be done carefully and methodically. Take particular care that no damage occurs to the klystron gun.***

(e) Orient the focusing coil unit (TE 1266) so that its cover plate is on the opposite side to the waveguide (i. e. on the same side as the ion getter pump).

(f) Carefully lower the focusing coil unit (TE 1266) over the klystron, ensuring that the guide pins underneath the focusing coil unit (TE 1266) fit into their respective locating holes in the klystron flange (Fig. 38).

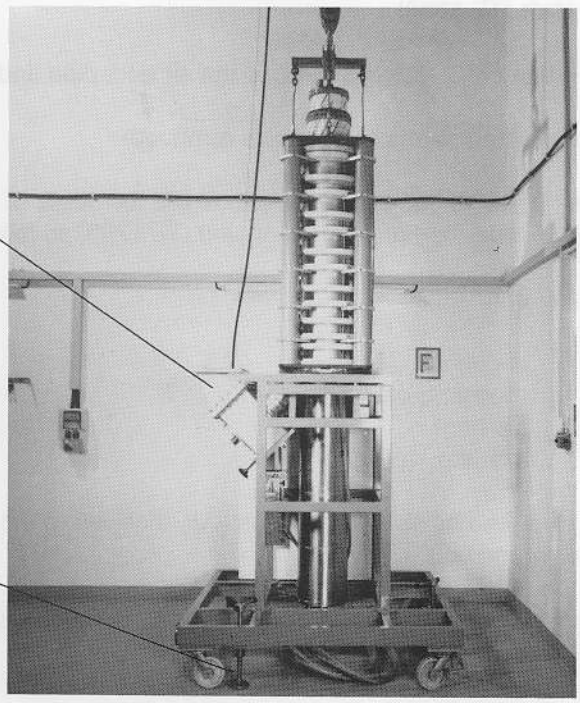


Fig. 38. The Focusing Coil Unit (TE 1266) in Position on the Klystron

g) Remove the lifting yoke (TE 1175) from the focusing coil unit (TE 1266) and from the hoist.

(h) Remove the four eye bolts from the top of the focusing coil unit (TE 1266).

(j) Finally fit the four pole-piece segments (Fig. 39) to the top of the focusing coil unit (TE 1266). Each segment slots inside its retaining bolt and should be pushed firmly against the klystron flange. The retaining bolt is then pushed inwards to retain the segment and finally tightened with an Allen key.

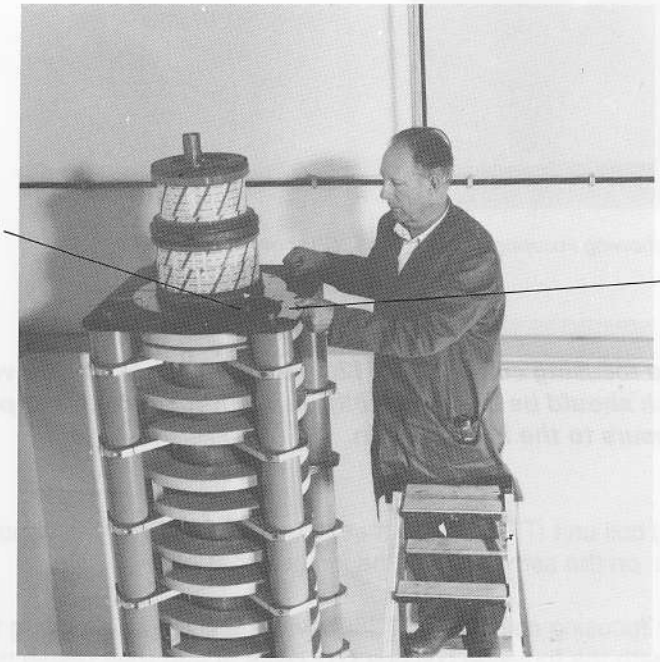


Fig. 39. Fitting the Four Pole-piece Segments

3.13. Mounting the HV Connection Unit (TE 1263)

(a) Unpack the HV connection unit (TE 1263) and remove the air duct pipe and plastic collar (see Fig. 45).
Open (or remove) the doors (photographs show doors removed)

(b) Unpack connecting cables (TE 1271) and connect them to the terminals of the four HV connectors (see Fig. 44) inside the HV connection unit (TE 1263) as follows:

cable length (mm)	connection
140	anode ring
280 (2 off)	(filament) cathodes
300	filament
(with clamp)	insulated terminal

(c) Attach lifting yoke (TE 1175) to the hoist and attach its four shackles to the four eye-bolts on top of the HV connection unit (TE 1263).

(d) Hoist the HV connection unit (TE 1263) above the klystron (Fig. 40) and orient it to customer requirements.

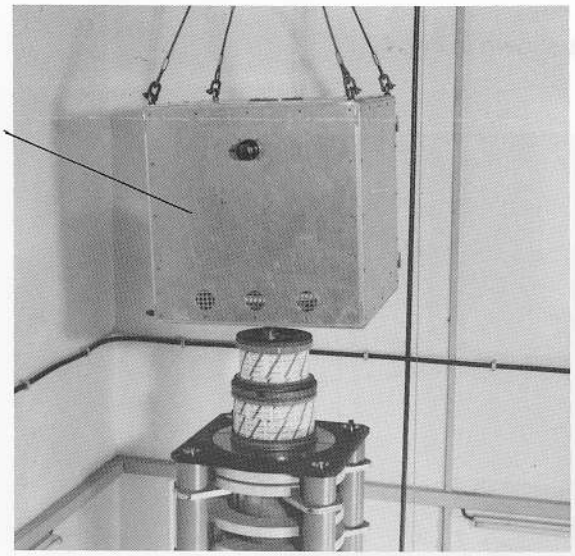


Fig. 40. Mounting the HV Connection Unit (TE 1263)

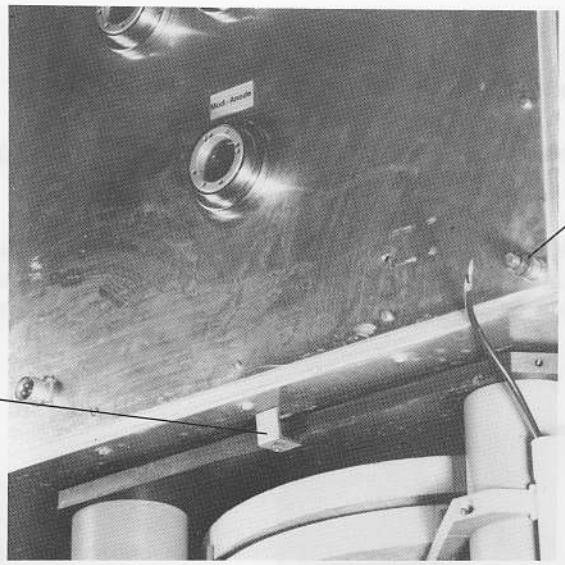


Fig. 41. Clamping the HV Connection Unit (TE 1263) to the Focusing Coil Unit (TE 1266)

(e) Carefully lower the HV connection unit (TE 1263) onto the focusing coil unit (TE 1266) so that the four holes in the bottom of the HV connection unit (TE 1263) fit over the nuts on top of the focusing coil unit (TE 1266). Due to the weight of the HV sockets the HV connection unit must be balanced by hand when lowering it. Avoid any contact to the gun!

(f) Secure the HV connection unit (TE 1263) to the focusing coil unit (TE 1266), using the two clamps, with screws, washers and spring washers from package P10 (paragraph 1.1(b)).

The clamps are fitted, one at the left and one at the right (Fig. 41).

(g) Remove the lifting yoke (TE 1175) from the unit and from the hoist.

(h) The fitted unit is shown in Fig. 42.

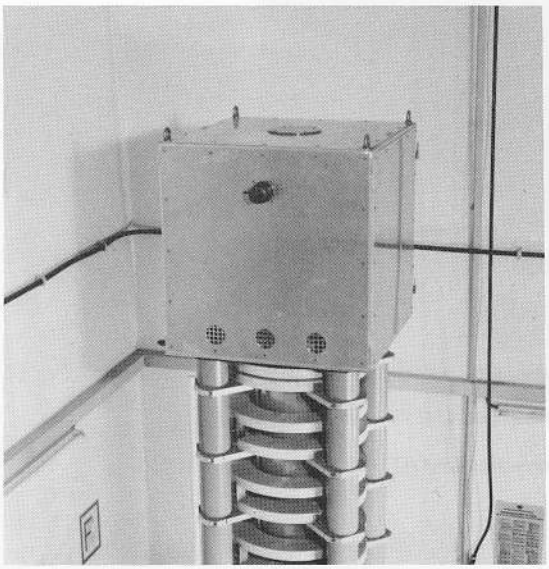


Fig. 42. Mounted HV Connection Unit (TE 1263)

3.14 Equipping the HV Connection Unit (TE 1263)

(a) Remove the protective paper from the klystron ceramics, taking care not to touch the ceramics.

(b) Unpack the accelerator anode ring (TE 1273) and fit it (inside the HV connection unit) over the anode of the klystron (Fig. 43). Use a srewdriver to open the slot in the ring and rotate it until the anode connecting cable lines up with the threaded hole in the anode ring.

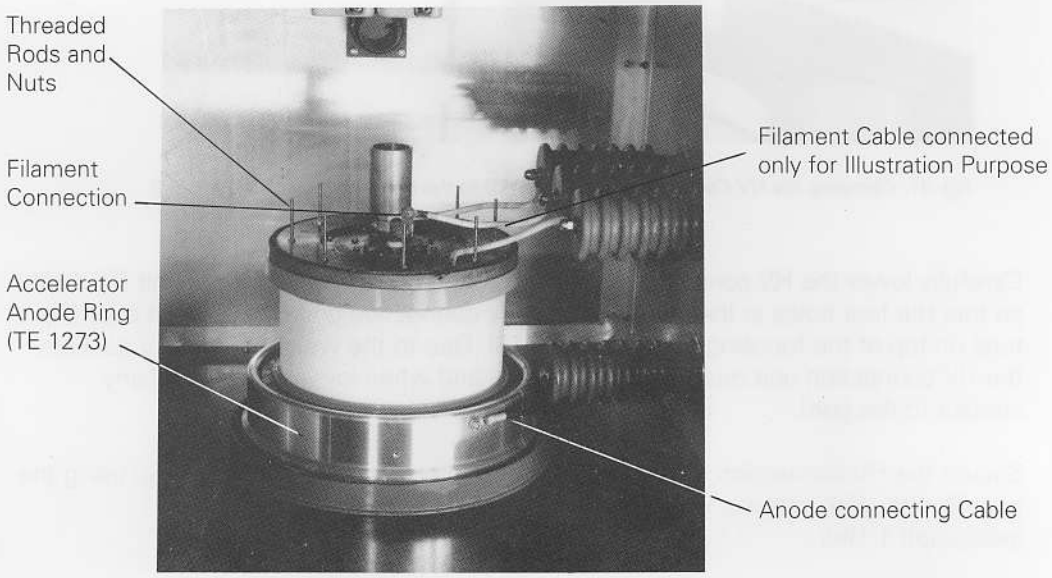


Fig. 43. Connecting the Anode Cable

(c) Connect the anode connecting cable to the anode ring (TE 1273).

(d) Open package P12 (paragraph 1.1.(b)) and remove the 8 M4 threaded rods and 8 nuts. Screw the 8 threaded rods into the top of the klystron (Fig. 43) and secure using the 8 nuts.

(e) Unpack the two parts of the cathode cooling ring assembly (TE 1274).

(f) Fit the lower part of the cathode cooling ring assembly (Fig. 44) over the threaded rods.

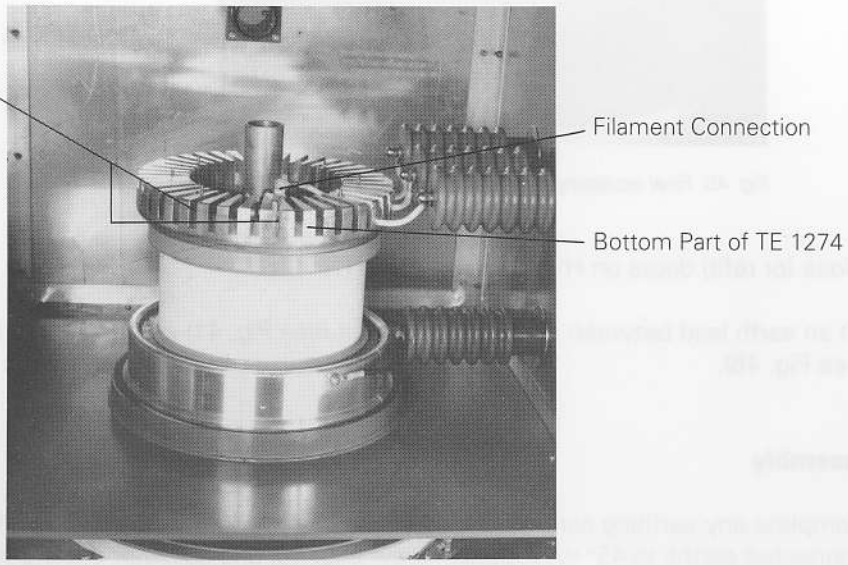


Fig. 44. Fitting the lower Part of the Cathode Cooling Ring Assembly (TE 1274)

(g) Take the 8 distance tubes from package P12 and place one over each of the threaded rods.

(h) Connect the filament clamp (Fig. 44) over the insulated filament terminal and tighten its screw (see also Fig. 2).

(j) Connect the filament/cathode and the cathode cables into two of the three tapped holes in the cathode, either side of the filament (see Fig. 2).

(l) Thread the cables between the fins of the lower part of the cathode cooling ring, as shown in Fig. 44.

(m) Fit the lid of the cathode cooling ring assembly (TE 1274) over the 8 distance tubes (Fig. 45) and secure using the 8 cap nuts and washers from package 12 (paragraph 1.1.(b)).

(n) Fit the air duct pipe (Fig. 45) to the lid of the cathode cooling ring assembly (TE 1274) and to the side-wall inlet of the HV connection unit (TE 1263).

(p) Fit the plastic collar (Fig. 45) around the accelerating anode ring, with the gap pointing towards the anode socket.

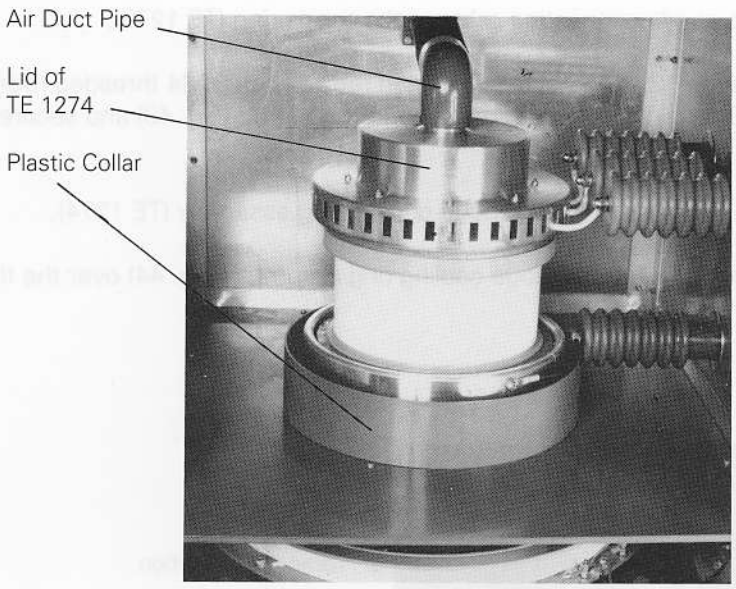


Fig. 45. Final equipping of HV Connection Unit (TE 1263)

(q) Close (or refit) doors on HV connection unit (TE 1263).

(r) Fit an earth lead between HV connection unit (see Fig. 41) and trolley earthing point (see Fig. 46).

3.15. Final Assembly

(a) Complete any earthing connections to the trolley (Fig. 46) including customer-connected earths to 45° waveguide elbow (Fig. 46) and collector cooling water inlet flange (Fig. 47).

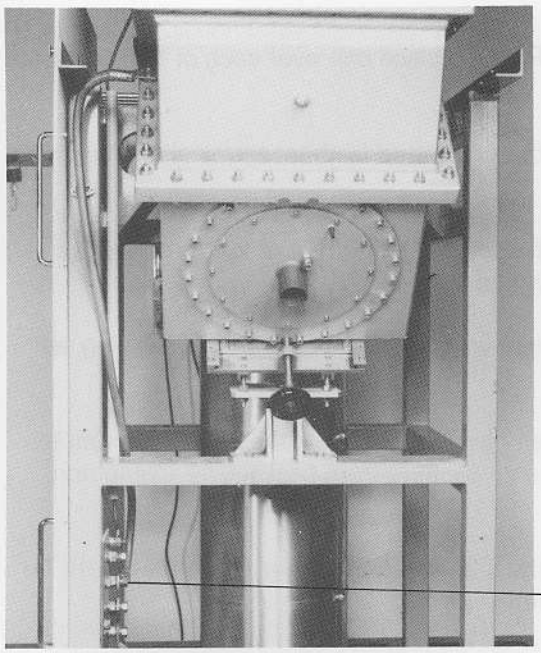


Fig. 46. Final Assembly (1)

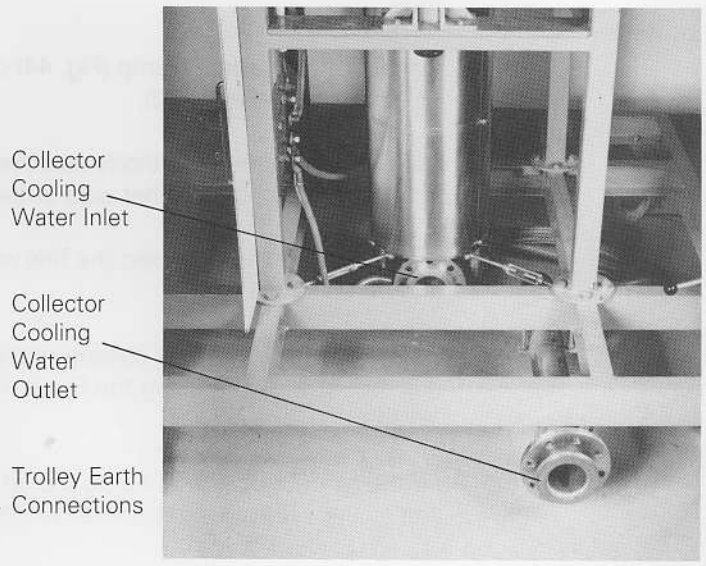


Fig. 47. Final Assembly (2)

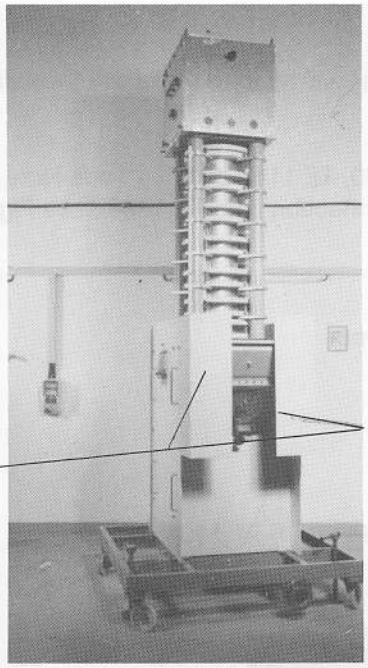


Fig. 48. Fitted angled Plates

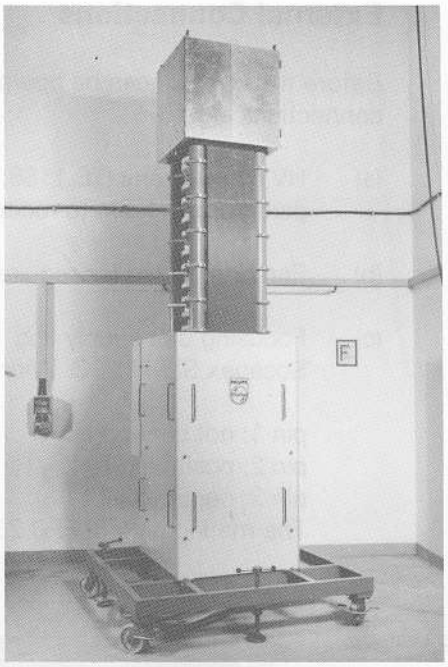


Fig. 49. Completed Assembly (1)

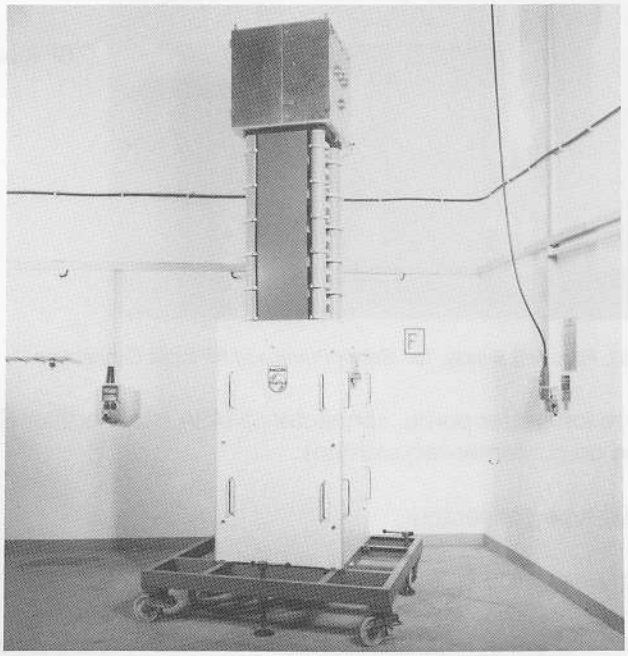


Fig. 50. Completed Assembly (2)

(b) Refit the three lead shielding plates as follows:
- front: 6 knurled screws and washers
- left 7 knurled screws and washers
- back (short: 2 knurled screws and washers

(c) Fit the two angled plates (Fig. 48), each with four bolts, washers and nuts.

(d) Completed assembly is shown in Figs. 49 and 50.

4. External Connections

Before the klystron can be operated, the customer will need to make the following connections:-

(a) HV connections (TE 1158, TE 1159, TE 1160, TE 1161 and P11 - see Note in paragraph 1.1.(a)), to receptacles on HV connection unit (TE 1263), see Fig. 54.

(b) Earthing cables (as required)

(c) Focusing unit supply (Fig. 51), connector type Socapex SLEM 23C. Wiring details:

pin 1: not connected
pin 2: positive (+)
pin 3: negative (–)
The mating plug SLFFD 23C (straight) is supplied in package P13.

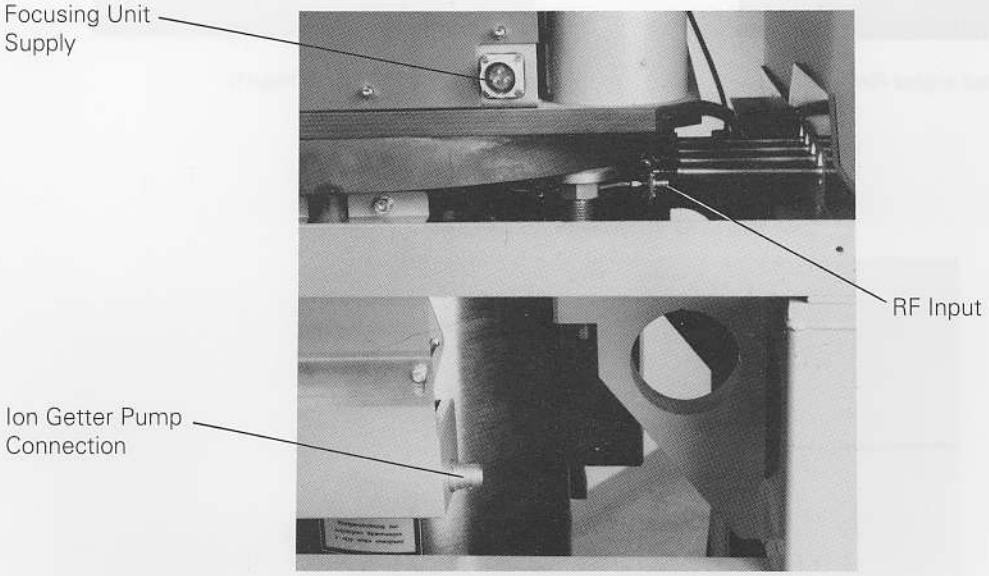


Fig. 51. Focusing Supply, Ion Getter Pump and RF Input Connectors

(d) HV cable to ion getter pump, connector UG49A (standard) or Radiall THT 20B, depending on customer-requirement.

(e) RF input (N-type connector).

(f) RF output waveguide (customer-configuration).

(g) Water inlet and outlet supplies to flanges of water cooling jacket (TE 1170) and water outlet collecting tube (TE 1168) respectively (see Fig. 47).

(h) Water connections (inlet and outlet) to body 1 and body 2 cooling circuit (Fig. 52).

(j) Body water temperature sensors (Fig. 52), if required.

(k) RF output window air-temperature sensor (Fig. 53).

(l) Air supply (Fig. 53) to RF window cooling-air inlet plate (TE 1165).

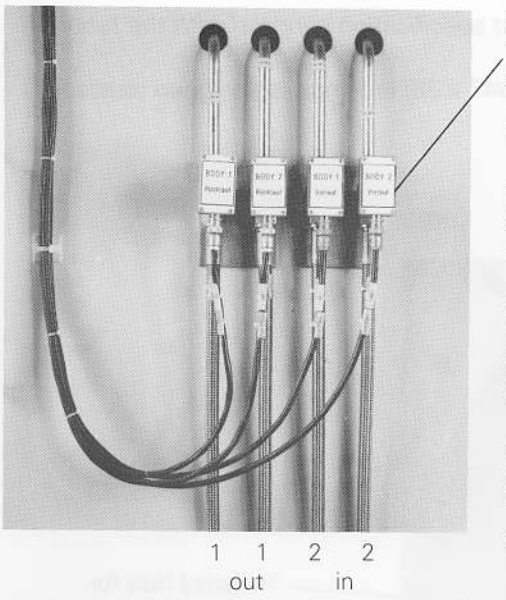


Fig. 52. *Typical Customer-Connection of Body Water Inlet and Outlet Hoses and Temperature Sensors*

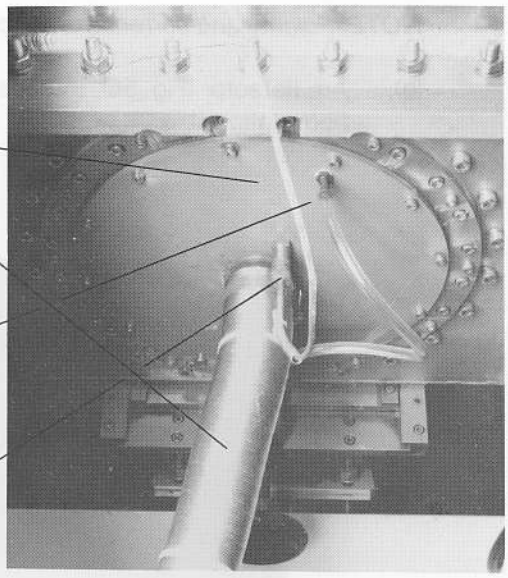


Fig. 53. *Typical Customer-Connections to RF Output Window*

(m) RF output window air-pressure sensor (Fig. 53). This interlock ensures that HV supplies cannot be switched on if RF window air supply is disconnected.

(n) Air supply (see Fig. 54) to HV connection unit (TE 1263).

(o) HV air pressure sensor (Fig. 54). This interlock ensures that heater power can not be switched on if HV air supply is disconnected.

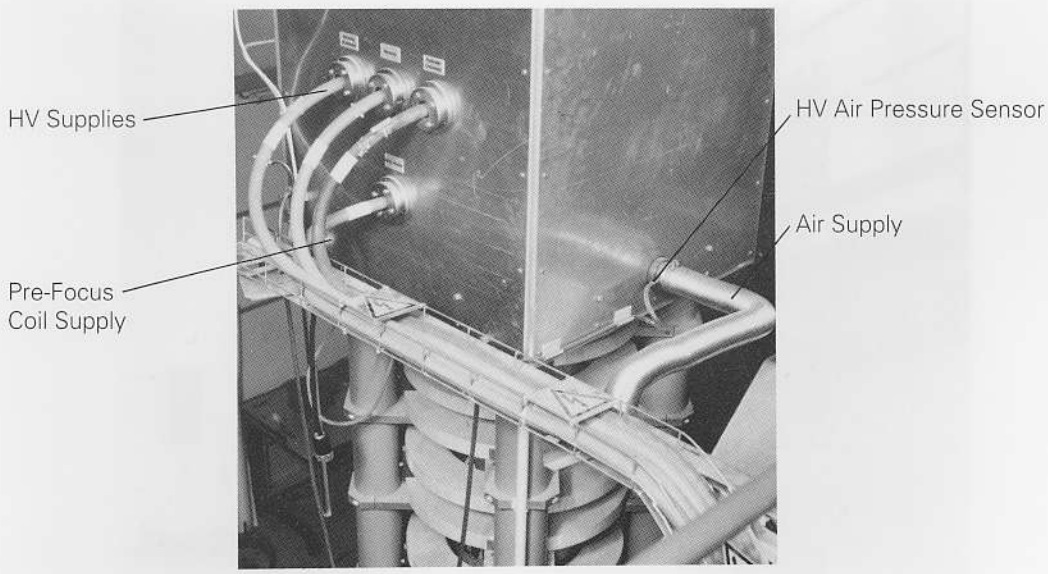


Fig. 54. *Typical Connections to HV Connection Unit (TE 1263)*

(p) Pre-focus coil supply (Fig. 54), connections:
Connector type Socapex SLEM 23 C
pin 1: positive (+)
pin 2: negative (-)
pin 3: not connected.

The mating plug SLFFC (angled) is supplied in package P13.

NOTE: *Polarity and current are specified in the test specification supplied with the tube.*

(q) Arc detector (Fig. 55), threaded hole (UNS 1/4" x 36) in flange is designed to accept fibre-optic cable.

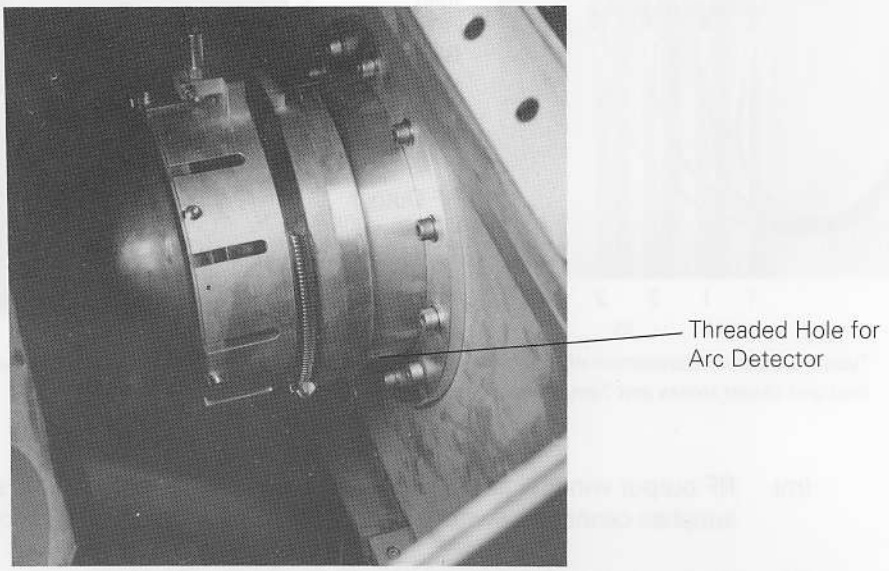


Fig. 55. Threaded Hole for Arc Detector

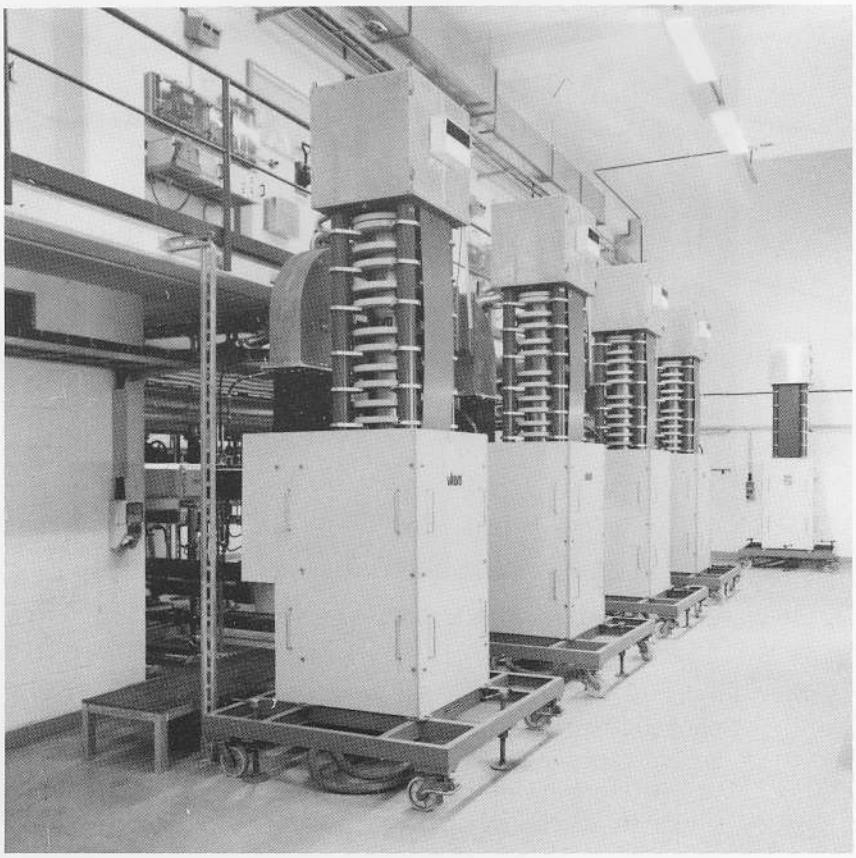


Fig. 56. Typical live installation

5. Typical Installation

(a) Figure 56 shows a typical live installation.

(b) Figure 57 shows the importance of regularly checking for RF radiation leakage, particularly around the waveguide

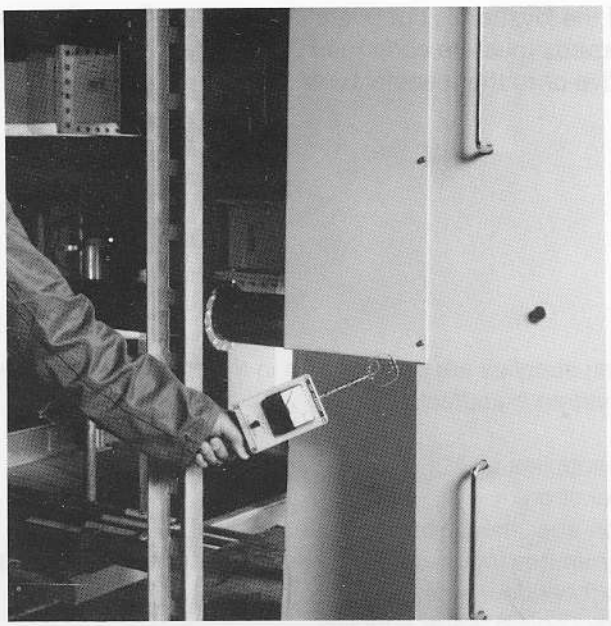


Fig. 57. Checking for RF Radiation Leakage

6. Operating the Klystron

6.1. WARNING:

Klystrons can be damaged by incorrect handling. It is therefore necessary to proceed carefully and according to instructions at all times. Do not attempt to operate this tube until it has been determined that all precautions have been taken to protect personnel from all hazards. Protective devices such as shields and interlock switch circuits must be in operation (see Annex A3).

6.2. HAZARDS!

6.2.1. R.F.-Radiation

Precautions should be taken to prevent exposing operating personnel to the strong R.F.-fields generated by this tube.

R.F.-Radiation may cause danger to the human body, particulary to the eyes.

R.F.-Radiation due to leakage can be prevented by correct mechanical practices to insure the integrity of **ALL** waveguide connections.

The R.F.-Radiation 1m away from from any part of the klystron at maximum output power should not exeed 0.1 mW/cm^2.

NEVER operate this tube without having the output waveguide properly terminated.

6.2.2. X-RAY-Radiation

Dangerous levels of X-ray radiation are produced by high power tubes.

Beam voltage must **never** be applied without having X-ray shielding in place. Basic X-ray shielding is an integral part of the tube and accessories. However the ultimate responsibility for X-ray shielding lies with the user.

Care must be taken in the assembly of the klystron unit to avoid any holes or slots. X-ray radiation may also increase if the klystron is not operating properly. Compliance with the local regulations regarding hazards must be confirmed by the user. If in any doubt refer to your local Philips representative or to the manufacturer.

6.3. Switching Sequence

6.3.1. Switching-on Sequence

It is important that the klystron supplies are switched on in the following sequence, unless otherwise agreed with the klystron manufacturer:

(I) Ion -getter pump supplies on.
(II) Air flow of HV socket on.
(III) Filament supply on after the pump current has fallen below 10μA.
(IV) Allow at least 15 minutes warm-up period before entering step (XI) (see note 2).
(V) Connect the output window air supply.
(VI) Connect both body cooling water supplies.
(VII) Connect collector cooling water supply.
(VIII) Connect focusing solenoid supply.
(IX) Check that the filament and the solenoid current is within ± 1% of the value given in the acceptance document (or measurement before the last switch-off).
(X) Connect the RF drive input (see note 3).
(XI) Connect the high voltage cathode (beam) supply and mod. – anode supply simultaneosly after the pump current has fallen below 10 μA.

NOTE 1: *Extended operation at an elevated pump current e.g. 1 μA or higher may reduce the klystrons' lifetime.*

NOTE 2: *In case of non-stabilized current supply for the prefoc. – coil a minimum warm up period of 15 minutes must be observed.*

NOTE 3: *No-drive (static) operation at a beam voltage exceeding 65 kV must be limited to a max. duration of 1 second.*

6.3.2. Switching-off Sequence

(I) Switch-off the high voltage mod. anode supply.
(II) Switch-off the cathode high voltage supply.
(III) Disconnect all other supplies and cooling circuits.

6.4. Operational Instructions

6.4.1. Inital Switch-on

Initial switch-on procedure must be carried out

after

(1) initial installation of the klystron at the transmitter site

but also after

(2) all changes of location, wiring and waveguide assembly,

(3) faults of tube operation in connection with heavy ion-getter current bursts, cathode emission drops, repeated HV-break-downs and window-arcs,

(4) all repair and reconditioning activities

and after

(5) regular interruption of operation for longer than 10 days.

The observation of the following instructions must be followed in order to avoid riscs to the cathode:

(a) Filament and solenoid currents must be set to the switching-on values given in the acceptance documents to within 1%. Prior to switching-on the HV **all** interlocks, safety circuits and their limiting value settings must be checked carefully. For initial switch-on ensure that focusing coil wiring and polarity is in accordance with the acceptance documents.

(b) Follow the switching-on steps 6.3.1. (I) to (X) but with the exception that the pump current must not be higher than 1 µA. Apply beam voltage of 30 to 50 kV. The anode voltage (with respect to cathode) should not exceed 60 % of the applied beam voltage. Adjust anode voltage so that a beam perveance of 0.8×10^{-6} $AV^{-3/2}$ is obtained. The RF drive power should be approximately 80 % of the value given in the klystrons' Test Documents for nominal operation. Maintain operation at this level for at least 10 minutes or until the ion getter current has fallen below 1 µA.

(c) Provided that no irregularities of tube performance occur, the beam voltage can be ramped-up slowly. The rate of the ramping-up procedure is subject to the value of the ion-getter current, which should be kept as low as possible, ideally below 1 µA.

Two modes for ramping-up can be used:

- raise beam voltage to its operating value. Then adjust the anode voltage to obtain the value of beam current according to the test documents,
- raise beam voltage and anode voltage simultaneously while keeping the beam perveance at the previously adjusted level.

After adjusting to the final beam data for full power operation the drive power should be adjusted for saturation of the RF output.

(d) A further fine adjustment of the anode voltage and RF drive power settings may become ecessary after a warm-up period of approximately 30 minutes before further tests are carried out.

It is recommended to register all relevant data and observations during the initial swich-on procedure and the performance tests.

(e) In the event of tube faults, HV break-down, window-arcs, gas bursts etc. the beam voltage should be reduced by approximately 10 kV for restarting after a normal getter ion current level (< 1 μA) has been reached.

6.4.2. Window Arcs

If arcs in the window or output section are repeatedly observed, although perfectly matched, the following could be the cause:

(I) High harmonic content

This can be caused for example by waveguide sections being resonant at harmonic frequencies. The voltage can then increase to a very high value due to the fact that normal waveguide loads, such as circulators or water loads, do not match at the harmonic frequencies.

(II) Humidity in the waveguide

Especially after long shut-down periods, arcs in the output line can be caused due to water condensation at the inner surfaces. It is therefore recommended that the output power is increased more slowly after extended shut-downs to allow the surfaces dry off.

(III) Contamination of the Window

Using a filter for the window cooling air (see Annex A 2) and a blower containing bearings lubricated with suitable high temperature grease, normally no window contamination is to be expected.

If contamination is suspected, and especially if at the same time the window temperature has increased, the window should be cleaned. Because this is a very delicate procedure, do not clean it before you have contacted the manufacturer for further information.

6.4.3. High-Potting of the Gun

WARNING: ***X-ray radiation may be caused by the high-potting procedure. Personnel must be protected by proper monitoring and shielding.***

In case of frequent internal high voltage break-downs a high-potting procedure may improve the klystron.

For high-potting a high voltage supply is connected across the mod. anode and body or cathode as shown in Fig. 58. The tube must withstand the max. test voltage (polarity as for normal operation) for at least 10 minutes without any internal arcs.

NOTE: *Unused high voltage sockets must be grounded or terminated by Dummy Plugs TE1161 (optional).*

The filament must not be energized and must be switched off at least two hours before the high-potting procedure.

The high-potting supply should be capable of delivering a voltage of 85 kV and a current of 3 mA, and must be equipped with a current interlock which is to be set to 3 mA.

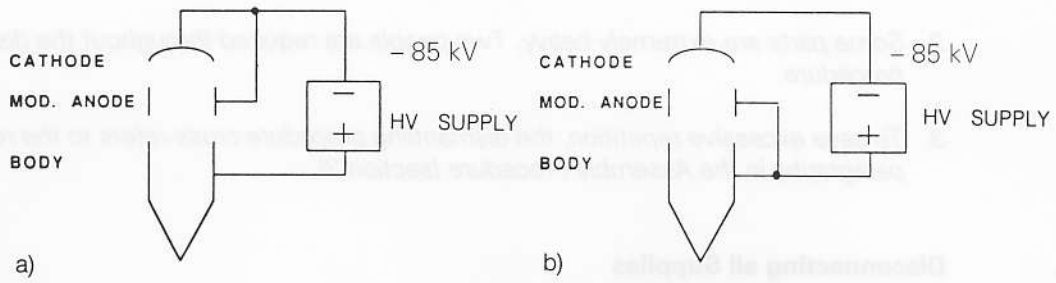


Fig. 58. High-Potting of the Gun

The following procedure is recommended:

1. Interconnect cathode and mod. anode or mod. anode and body and apply the HV supply as shown in Fig. 58.

2. Connect the ion-getter pump throughout the procdure.

3. Switch on the HV supply and increase the voltage slowly, starting from zero, until the current interlock is activated due to over-current. or the ion-getter pump current exceeds 2 μA.

4. Do not increase or restart the HV supply before the pump current has fallen below 2 μA.

5. High-potting will be completed when, at the final test voltage, the pump current is less than 1 μA and the tube withstands the HV for at least 10 minutes for both cases illustrated in Fig 58.

6.4.4. Adjustment of Filament Current during Life

After an operation period of about 300 to 500 hours the vacuum quality of the klystron will have improved, so that the tube can be operated at lower filament power. At this point the filament current can be reduced by approximately 5%. The optimum is found if the beam current has dropped by 2% with respect to the initial value and proves to be stable under this condition for a period exceeding 1 hour. The filament current must be determined for the highest possible beam current during operation.

For detailed information see Philips Technical Note "Operation of dispenser cathodes in high-power klystrons" or contact manufacturer.

NOTE: *In case of klystrons equipped with a "Low Temperature Cathode" (see Test Documents supplied with the tube) please contact manufacturer.*

7. Replacing the Tube

NOTES:

1. *The procedures described here should be used to replace a tube.*
2. *Some parts are extremely heavy. Two people are required throughout the dismantling procedure.*
3. *To save excessive repetition, the dismantling procedure cross-refers to the relevant paragraphs in the Assembly Procedure (section 3).*

7.1. Disconnecting all Supplies

(a) Switch off all electrical, air and water supplies to the equipment.

(b) Disconnect all external connections (Section 4).

7.2. Removing the HV Connection Unit (TE 1263)

(a) Position the hoist above the klystron.

(b) Open the doors of the HV connection unit (TE 1263), or remove them.

(c) Discharge any static electricity.

(d) From inside the HV connection unit, remove (paragraph 3.14):

- plastic collar
- air duct pipe
- lid and base of cathode cooling ring assembly (TE 1274) and fixings
- accelerator anode ring (TE 1273)

NOTE: *Take care not to touch the gun ceramics.*

(e) Fit lifting yoke (TE 1175) to the hoist and attach its four shackles to the four eye-bolts on top of the HV connection unit (TE 1263).

(f) Disconnect the two clamps, screws, washers and spring washers (Fig. 41) which secure the HV connection unit (TE 1263) to the focusing coil unit (TE 1266).

(g) Carefully hoist the HV connection unit (TE 1263) off the focussing coil unit (TE 1266).

(h) Lower it to the ground and remove the lifting yoke from the HV connection unit (TE 1263).

7.3. Removing the Focusing Coil Unit (TE 1266)

(a) Fit the four eye-bolts (paragraph 3.12) to the top of the focusing coil unit (TE 1266)

(b) Unscrew the retaining bolts and remove the four pole-piece segments (Fig. 39) from the top of the focusing coil unit (TE 1266).

(c) Reposition the hoist above the klystron and fit the four shackles of lifting yoke (TE 1175) onto the four eye-bolts on top of the focusing coil unit.

(d) Using extreme care, slowly and carefully hoist the focusing coil unit (TE 1266) off the klystron.

(e) Lower it to about 1 metre from the ground and fit the two undercarriages (four nuts).

(f) Place the focusing coil unit (TE 1266) on the ground.

(g) Remove and discard the lifting yoke (TE 1175).

(h) Remove the four lead shielding plates (paragraph 3.15.) and angled plates (Fig. 48).

7.4. Removing the Coaxial/waveguide Transition (TE 1164B)

(a) Disconnect the external waveguide and all connections from the RF output window (including earth connection from waveguide elbow).

(b) Remove the RF output window cooling air inlet plate (TE 1165) by disconnecting 12 bolts and washers (paragraph 3.11).

(c) Disconnect the 12 bolts from the coaxial inner conductor.

(d) Remove the coaxial/waveguide transition (TE 1164B) from the RF output window flange by disconnecting 12 bolts and washers.

(e) Carefully rotate the large black knob (Fig. 31) anticlockwise, while separating the flanges (Fig. 33) until the coaxial/waveguide transition (TE 1164 B) is loose.

(f) Remove the coaxial/waveguide transition (TE 1164B) together with its 45° waveguide elbow.

7.5. Removing Trolley Connections

(a) Remove the four (customer-connected) extension pipes (Fig. 29) from the body 1 and 2 inlet and outlet connections of the klystron.

(b) Disconnect the interconnecting water hoses (TE 1169) from the collector water cooling jacket (TE 1170) (paragraph 3.10).

(c) Disconnect the earth connection from the threaded stud on the collector flange.

(d) Remove the three braces (Fig. 27) from the collector by disconnecting the special shoulder screws, insulating bushes and insulating washers.

7.6. Fitting the Support Flange and Body Supports to the Klystron

(a) Fit the lifting yoke (TE 1176) to the hoist and fit the support flange (Fig. 26) to the yoke, secured by the two safety pins.

(b) Lower the support flange over the klystron and fix it to the klystron, using four securing bolts and washers (paragraph 3.9).

(c) Refit the two body supports (Fig. 25) to the klystron using four bottom bolts and washers (Fig. 26).

(d) Close the clamp and secure using four clamp securing bolts (Fig. 25).

(e) Tighten the two top supports (Fig. 25).

7.7. Hoisting the klystron and its collector water cooling jacket (TE 1170) from the trolley

(a) Carefully hoist the klystron and its collector water cooling jacket (TE 1170) out of the trolley

(b) Fit the three support legs (TE 1170S) to the collector water cooling jacket (TE 1170)

(c) Remove the trolley and lower the klystron and its collector water cooling jacket until it just touches the ground

7.8. Hoisting the klystron out of its collector water cooling jacket (TE 1170)

(a) Remove the 12 screws and washers from the collector flange (paragraph 3.6.).

(b) Very carefully hoist the klystron out of its collector water cooling jacket (TE 1170).

(c) If required, remove the three support legs (TE 1170 S) from the collector water cooling jacket (TE 1170).

7.9. Fitting the klystron into its support frame (TE 1177)

(a) Position the support frame (TE 1177) directly beneath the hoisted klystron (Fig. 16)

(b) Gently lower the klystron into its support frame (TE 1177) and secure using four nuts (paragraph 3.5.).

7.10. Lowering the klystron to the horizontal position

(a) Read the CAUTION in paragraph 3.4.

(b) Fit the wire hawser between the hoists and the collector supporting frame.

(c) Taking extreme care, start to lower the klystron (Fig. 13)

(d) Support it carefully until it reaches the horizontal position (on the floor, Fig. 11)

7.11. Hoisting the klystron onto its transport trolley (TE 1178)

(a) Carefully hoist the klystron onto its transport trolley (paragraph 3.3.) as shown in Figs. 3, 4 and 5.

(b) Secure the fixing clamp around the support flange of the klystron (Fig. 7), using the nut and washers.

(c) Refit the yellow transport clamps to the collector end and gun end, using 2 nuts and washers for each clamp.

(d) Remove the wire hawser, lifting yoke and hoist

(e) Tighten lateral retaining bolts (see Fig. 7).

NOTE: *To avoid a possible damage of the tube during transport by freezing water blow out any residual water from the body cooling circuits.*

8. Annex

A 1. Water Specification for Water Cooling of Body and Collector

A 1.1. Water Quality

In general the water quality must be meet the following specifications:

Conductivity:	$< 3 \cdot 10^{-6}\ \Omega^{-1}\ cm^{-1}$ (intial value for refilling)
at room temperature:	$< 10 \cdot 10^{-6}\ \Omega^{-1}\ cm^{-1}$ (limiting value in the storage tank)
	$< 100 \cdot 10^{-6}\ \Omega^{-1}\ cm^{-1}$ (limiting value in the boiler),
pH - value:	≤ 7 (i.e. acidic, not alkaline),
dissolved solids:	10 ppm max. (organic content 1 ppm max.),
mineral and silicone oil/grease content:	1 mg per litre max.,
chloride and carbonate content::	0.5 ppm max.(intial value for refilling).

NOTE: *The conductivity is the most important parameter and should be monitored.*

After each water change or system cleaning or if any deterioration of the water by detergents or organic matter is suspected, which may degrade the interfacial tension of water, a foaming test should be carried out.

A 1.2. Foaming Test

After each water change or system cleaning or if any deterioration of the water by detergents or organic matter is suspected, which may degrade the interfacial tension of water, a foaming test should be carried out.

A 13 mm diameter glass test tube with a rubber stopper and a one print sample bottle with a cap are needed. Both must be clean.

1. Run the cooling system for about half an hour until the water is thoroughly mixed.
2. Drain a sample of the water into the bottle and allow to cool to room temperature. If the water is left standing for more than an hour, slowly invert the capped bottle WITHOUT SHAKING it.
3. Rinse the test tube and the stopper three times with the sample water.
4. Half fill the tube with water and put the stopper in.
5. Shake vigorously for 15 seconds using three up and down motions a second. Allow to stand for 15 seconds then compare with sketches Fig. A1 A, B and C.

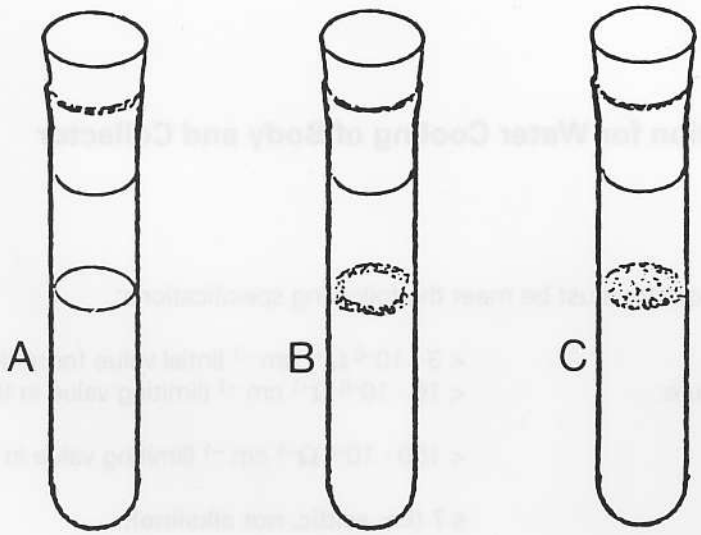


Fig. A1. Test Tube for Foaming Test, Sketch of Water Surface

Sketch A A complete foam free surface indicates that no producing impurities are present.

Sketch B A circle of clear water in the centre but some foam at the test tube wall indicates a temporarily acceptable level of impurities. A second test should be made one week later.

Sketch C If the foam layer completely covers the water surface the system should be flushed again.

A 1.3. Anti-Freeze Water Specification for Body Cooling

In case the ambient temperature is such that the pure water will freeze, a mixture of water and commercial anti-freeze preparation such as Glysantin (BASF), Dowcal 10 and Dowtherm SR-1 (Dow Chemical) are recommended. Other glycol preparations may also be used in case the manufacturer states, that the glycol preparation contains adequate corrosion inhibitors for the metals used in the cooling system.

NOTES:

1. *In cooling systems containing a purification loop, which continously purifies the coolant, a mixture of uninhibited (technical grade) ethylene glycol and water must be used. Inhibited ethylene glycols should not be used, since the inhibitors would immediately saturate the ion exchange resin and render it useless.*

2. *Glycol anti freeze mixtures are liable to thermal degradation during time of use, especially when the coolant is oxigenated. It is advisable to monitor the pH-value regularly. The coolant mixture is to be replaced as soon as it turns acidic at least once a year. Flush the cooling system before refilling.*

   Cooling system designers should ensure that oxigenation of the coolant is avoided whenever possible, e.g. by ensuring that return pipes discharge below the level of coolant in the reservoir tank.

A 2. Cooling Air Quality Requirement

For cooling the R.F. output window section filtered and dry air must be supplied. The filter efficiency for 1 micron particles must be at least 70%. An effiency of 98% is recommended. The filter should be exchanged at adequate time intervals depending on the quality of the input air. It is advisable to monitor continuously the pressure drop across the filter.

A 3. Safety Interlocks

A 3.1. Overcurrent and Overvoltage Protection of the Klystron

In order to protect the klystron against damage under fault conditions, the customer must supply overcurrent and overvoltage protection.

Under no circumstances must the energy supplied to the tube exceed 40 joules (or the area under the beam current /time curve $\int I^2 dt$ exceed 40 A^2s).

Specific crowbar circuit design is the customers' responsibility, however the following test should be applied:

If the klyston is replaced by a piece of copper wire of 0.35 mm diameter and length of 1 cm/kV, the copper wire must not be destroyed if the full beam voltage is applied across the wire.

(I) The crowbar circuit must be designed to divert any overcurrent from the tube within 100 µs under either of the following conditions:

- if the beam current increases at a rate greater than 10 A/µs,
- if the focusing solenoid main field current deviates more than ± 5% from the value recorded in the acceptance document.

(II) The customer must supply protection circuitry to switch off the beam voltage within 100 ms under the following conditions:

- if the beam current exceeds 18.5 A or if it increases by more than 2A above the set value,
- if the ion getter pump current exceeds 10 μA,
- if the monitored temperatures or temperature differences of the body or collector cooling circuits exceed the limiting values,
- if the flow rate of the collector cooling water falls below 600 litres per minute,
- if the flow rates of the body cooling water fall below 10 resp. 20 litres per minute,
- if the air flow rates at the output window falls below 1.5 m^3 per minute,
- if the window temperature difference between air input and output exceeds 35 K.

A 3.2. Protection in Case of RF-Faults

The customer must provide protection circuitry to disconnect the RF drive within 10 μs and - in case of operation above 65 kV - to switch off within 100 ms the DC input power or to reduce the beam voltage to 65 kV observing a limiting of 850 kW within 100 ms.

This applies the following conditions:

- if the arc sensor is activated, or
- if the RF reflection indicator shows a fault condition in the waveguide VSWR > 1.2.

A 3.3. Protection of the Filament

In order to protect the filament from damage under fault conditions, the customer must provide a protection circuit which will switch off the filament supply within 1 second if the ion getter pump current exceeds 1 mA.

A 3.4. Restarting

After any interlock circuit has tripped under fault conditions, restarting must not take place until at least 10 seconds have elapsed. Under certain conditions this restart time could be reduced with the permission of the klystron manufacturer.

A 4. Temperature Differences for Limiting Values of Collector and Body Dissipation

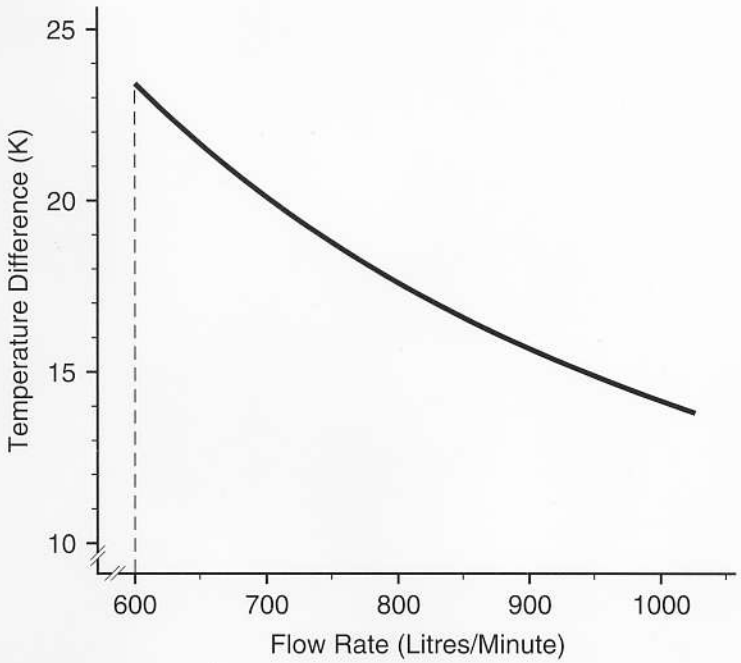


Fig.59 . Maximum Temperature Difference between Inlet and Outlet versus Collector Cooling Water Flow Rate for maximum Collector Dissipation 850 kW

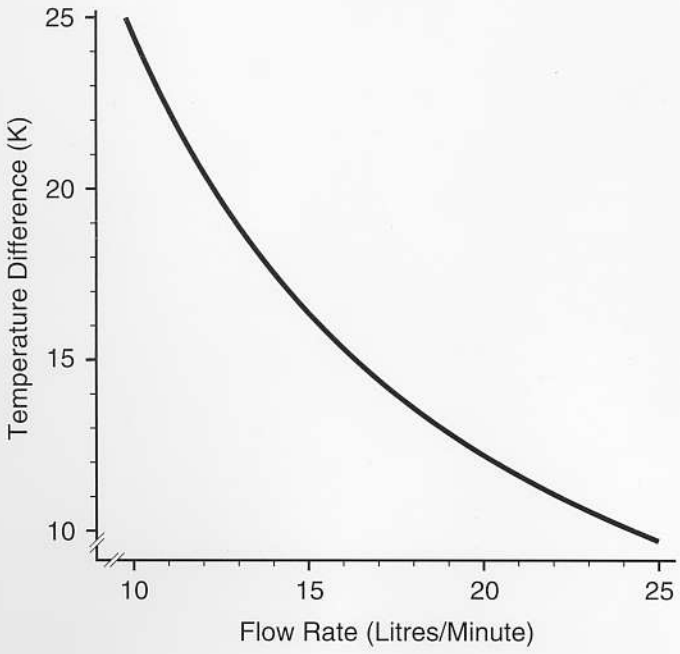


Fig.60. Maximum Temperature Difference between Inlet and Outlet versus Body Cooling Water Flow Rate for maximum Body Dissipation 15 kW