ESCIOT5130W
EEV Depressed Collector Plug-in IOT Amplifier for UHF TV Service

FEATURES

- **Plug-in Tube** ESCIOT plugs into a fully-assembled and tested input and output cavity system. No output cavity assembly required.
- **Operable as a Digital or an Analogue Amplifier**
- **Output Power** Specified as a digital amplifier for average powers up to 35 kW. Rated as a common amplifier up to 66 kW peak sync. vision plus 6.6 kW single carrier aural. Rated as a vision amplifier to 66 kW.
- **Frequency Range** 470 to 810 MHz (Bands IV and V) in a single tube and circuit.
- **Energy Saving Collector** State-of-the-art energy saving collector provides best cost of ownership by optimising tube efficiency.
- **Long Life** High reliability electron gun with barium aluminate cathode and pyrolytic graphite grid.
- **Simple, Efficient Cooling** Air-cooled cavities, collector stage 5 and gun. Water cooled body. High purity water cooled collector stages 1, 2, 3 and 4.
- **Plug-in Tube Exchange** Continuously tunable external cavities, with digital frequency indicators. A single operator can exchange the ESCIOT quickly, without removing any cavities.
- **Easy to Tune Input Cavity** Input cavity has a single tuning control and a single matching control. No additional matching components required.
- **All Ceramics Aluminium Oxide** No beryllium oxide hazard.

DESCRIPTION

ESCIOT5130W is a high efficiency plug-in Inductive Output Tube amplifier for use in the output stage of transmitters in UHF television service.

The ESCIOT has an electromagnetically focused electron beam which is density bunched using a rugged grid driven by an RF cavity. The ESCIOT beam power varies with the instantaneous output power.

The circuit assembly is designed to accept a plug-in ESCIOT. The circuit is shipped with all input and output cavities fully assembled. If the required channel is known, the circuit can be shipped coarse tuned to the channel. Tube replacement time is reduced to a minimum and can be undertaken by a single operator. The ESCIOT can be removed from the complete circuit assembly without removing any of the cavities first. The replacement ESCIOT is coarse tuned at switch-on and requires only trimming adjustments. A feature of the cavity design is that tuning of each output cavity is by means of a single knob.

The electron gun, body, collector 5 and cavities require forced-air cooling; the circuit assembly incorporates a distribution manifold for which the cooling air must be adequately filtered to avoid electrostatic precipitation of dust on insulators.

The ESCIOT collector is water cooled and the exit water must be led to a separate heat exchanger (not supplied).

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ABRIDGED DATA

Frequency range	470 to 810	MHz
Power gain (see note 1)	20.5 to 24	dB
Beam voltage	28 to 38	kV

Digital

Peak output power at ESCIOT flange	up to 145	kW
Average output power (corrected) at ESCIOT flange (see note 2)	up to 33	kW

Analogue

Output power (common amplification) (see note 3)	up to 66 kW vision + 6.6 kW aural	
Output power (vision only)	up to 66	kW

GENERAL

Electrical

Cathode	indirectly heated	
Heater voltage (see note 4)	5.75 to 6.5	V dc
Heater current range	24 to 30	A
Cathode pre-heating time	10	minutes
Ion pump to collector voltage	+3.0 to 4.0	kV
Internal impedance of ion pump supply	500 kΩ approx	

Mechanical

Overall length	96.0 cm (37.8 inches) nom
Overall breadth	31.0 x 31.0 cm (12.2 x 12.2 inches) nom
Mounting position	vertical, collector end up
Net weight of ESCIOT	65 kg (143.3 pounds) approx

Circuit Assembly

Electromagnet voltage	5.0 to 7.0	Vdc
Electromagnet current	26 to 28	A
RF input connector	type N coaxial (female)	
RF output	EIA $3\,^1/_8$ inch 50 Ω coaxial line	
Net weight of tuning cavities	40 kg (88 pounds) approx	
Net weight of magnet assembly	113 kg (250 pounds) approx	

Cooling

Air flow to cavities, cathode terminal and collector 5 (see note 5)	3.5	m^3/min
	123.6	cfm
Static pressure head (see note 6)	1.27	kPa
	5.1	inches w.g.
Inlet air temperature	60	°C max
Minimum water flow required for body	6	l/min
	1.59	US gal/min
Anode pressure drop at 6 l/min	145	kPa
	21	psi
Minimum water flow required for collector	40	l/min
	10.6	US gal/min
Pressure drop across collector at 40 l/min (see note 7)	200	kPa
	29	psi
Inlet pressure	400	kPa max
	58	psi max
Water outlet temperature	70	°C max
Water inlet temperature	55	°C max

Tube Protection

Arc detector type MA257E is fitted to each of the primary and secondary output cavities. The beam voltage and drive power must be removed within 100 ms of an arc being established.

Photo-resistor type	VT43N2	
Minimum dark resistance	10	MΩ
Resistance at 10 lux	8 to 24	kΩ
Maximum voltage (peak)	250	V
Maximum temperature	75	°C
Layer	cadmium sulphide	
Test lamp	28	V
	0.04	A
Connections	see page 5	

MAXIMUM RATINGS (Absolute values)

The transmitter must be provided with a fast disconnect circuit which operates in the event of an internal gun arc (see note 8). If the maximum rating for any of the other parameters listed below is exceeded, the beam voltage must be removed within 100 ms from the instant at which the rating is exceeded. In either case, the beam voltage must not be re-applied within 5 seconds.

Heater starting current (peak)	60	A
Beam voltage (see note 9)	40	kV
Beam current (mean)	3.3	A
Quiescent current	800	mA
minimum (see note 10)	100	mA
Load VSWR (see note 11)	1.5:1	
Grid to cathode bias voltage	−250	V dc
Grid current	±150	mA
Ion pump current (beam on)	20	μA
Collector voltage (with respect to ground) (see note 12):		
collector 5	40	kV
collector 4	24	kV
collector 3	18	kV
collector 2	0	kV
collector 1	0	kV
Collector current:		
collector 5	20	mA
collector 4	1.4	A
collector 3	1.1	A
collector 2	1.4	A
collector 1	500	mA
Maximum intercollector voltage	25	kV

Digital

Peak drive power (see note 13)	1.7	kW
Average drive power	300	W
Average output power:		
corrected	33	kW
uncorrected (setup only)	36	kW

Analogue

Peak sync. output power	66	kW
Drive power (peak sync.) (see note 13)	600	W

Other Ratings

Altitude (see note 5)	2286	m
	7500	ft
X-ray radiation (see Health and Safety Hazards, page 5)	2	μSv/hr

TYPICAL OPERATION – Digital
(See note 14)

Peak output power	107	130	149	kW
Average output power	20	25	32.5	kW
Peak input power	779	909	1004	W
Average input power	129	149	144	W
Beam voltage (see note 15)	31.5	34	36	kV
Collector depressions:				
collector 5	100	100	100	%
collector 4	50	50	50	%
collector 3	30	30	30	%
collector 2	0	0	0	%
collector 1	0	0	0	%
Collector currents:				
collector 5	0.3	0.3	0	mA
collector 4	0.84	0.95	0.82	A
collector 3	0.47	0.5	0.52	A
collector 2	0.39	0.4	0.59	A
collector 1	128	142	207	mA
Quiescent beam current (see note 16)	600	600	600	mA
Grid bias voltage with respect to cathode			see note 17	
Efficiency	50	54	57	%

TYPICAL OPERATION – Analogue
(System M)
Common Amplifier Service (Mono Sound)
(See notes 3 and 18)

Visual output power	67.8	67.8	66.7	kW
Aural output power	0	3.4	6.7	kW
Beam voltage	36	36	36	kV
Collector depressions:				
collector 5	100	100	100	%
collector 4	50	50	50	%
collector 3	30	30	30	%
collector 2	0	0	0	%
collector 1	0	0	0	%
Quiescent beam current	600	600	600	mA
Grid bias voltage with respect to cathode			see note 17	
Collector currents (black + sync. + aural):				
collector 5	0.5	0.3	0.3	mA
collector 4	0.81	0.80	0.94	A
collector 3	0.86	0.74	0.73	A
collector 2	0.63	0.82	0.87	A
collector 1	206	231	245	mA
Collector currents (mid-grey):				
collector 5	0.4	0.3	0.3	mA
collector 4	1.10	0.92	0.98	A
collector 3	0.29	0.47	0.52	A
collector 2	0.25	0.33	0.39	A
collector 1	95	143	162	mA
Drive power:				
vision peak sync.	336	344	334	W
aural	0	27	45	W
Figure of Merit (see note 19)	172	157	145	%

NOTES

1. In digital operation, the peak gain is typically 20.5 dB and the average gain is typically 22.5 dB.
2. The available corrected output power varies slightly as a function of frequency. The relationship is shown in Fig. 1.

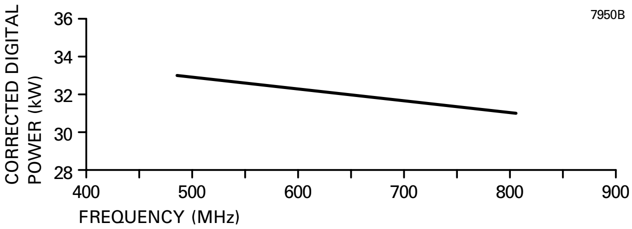


Fig. 1. ESCIOT5130W typical power characteristic

3. Common amplifier service is the use of a single ESCIOT to transmit both the visual and aural services. The data assumes that a single sound carrier is being transmitted. The peak instantaneous RF output is calculated by the formula:

   $P = V(1 + \sqrt{A})^2$

   where P is the peak RF output power, V is the peak sync. visual output power and A is the ratio of carrier aural power to peak sync. visual power.

   If two aural carriers are to be transmitted, the peak instantaneous RF output power is calculated by the formula:

   $P = V(1 + \sqrt{A} + \sqrt{S})^2$

   where S is the ratio of second aural carrier power to peak sync. visual power.

4. **Heater Voltage**

   The actual heater voltage to be used on a particular ESCIOT5130W is advised with the tube. The heater voltage should be stabilised to within ± 0.15 V of the recommended value. Re-entrant cables are provided to monitor this voltage.

   At initial installation, the heater voltage should be set to the value stated on the customer test sheet. After 400 hours of operation, the heater voltage should be reduced by 0.25 V. If the tube exhibits high interceptive grid current, the heater voltage should be raised by 0.1 V.

   Passive Standby and Quick-Start Modes

   Passive standby is defined as any time period exceeding 30 minutes when the ESCIOT is operated without beam voltage present but with the heater powered. The ion pump and all cooling must be operated normally in this situation.

   Where an ESCIOT is being used in a passive standby transmitter, several options exist for the mode of ESCIOT passive operation:

   Background Heat Passive Standby Mode

   The ESCIOT5130W must be operated with a Background Heat filament voltage 0.75 V less than the nominal heater voltage advised on the test record for a particular ESCIOT, and in no circumstances should the Background Heat heater voltage be less than 5.0 V.

   If a passive standby transmitter is needed for transmission, the heater voltage should be raised to its rated value and other auxiliary supplies activated. Provided that the grid bias voltage is present, the beam voltage and RF drive may be applied to the tube simultaneously. Precautions must be taken to ensure that the ESCIOT is not overdriven, for example by disabling the transmitter a.g.c. system for a period of about five minutes.

   Background heat must have been applied for at least 30 minutes from cold start before the transmitter can be considered available for transmission. Alternatively, both "Active" and "Standby" transmitters may be started from cold using the normal start procedure. The "Standby" transmitter is then switched to Background Heat and is available to take over transmission if required.

Where Background Heat Passive Reserve is the normal operating mode with a pair of identical transmitters, the transmitter designated as "Standby" must become the "Active" transmitter after a period not exceeding 14 days and must remain designated "Active" for a period of not less than 7 days.

If a hydrogen thyratron crowbar is used in the "Standby" transmitter it should be permanently powered to full operational status.

Filament hours accumulated under Background Heat conditions do not normally count as warranty hours, provided that the above conditions are met and that there are proper means to distinguish Background Heat hours from normal heater hours.

"Soft Start"

It is recommended that a "soft start" procedure should be used in the application of the RF drive when the ESCIOT is powered either from cold or from background heat.

The RF drive may be applied simultaneously with the beam voltage and with a typical rise time of 4 seconds.

Near-instantaneous Start - Quiescent Passive Standby

A nearly instantaneous start from standby can be achieved by operating the "Standby" transmitter in a quiescent passive standby mode where the RF drive only is removed from the ESCIOT and the tube operates with the normal beam voltage applied. The tube draws a quiescent current (which may be lower than the normal value). This slightly reduces overall system efficiency, but ensures that the standby tube is maintained in good condition and is available for near-instant start, subject to normal soft start conditions.

The minimum quiescent current that should be used in this mode is 100 mA. This will ensure the tube maintains a good vacuum and life in standby mode.

Mains Interruptions

If mains power is absent for less than or equal to 20 seconds, then the transmitter may be re-powered immediately, provided that the transmitter logic is active and the power supplies are therefore re-applied in the correct order.

If mains power is absent for between 20 seconds and 5 minutes, then heater voltage should be re-applied for an equal length of time, before attempting to re-power the ESCIOT, which should then be powered in the normal way.

If mains power is absent for more than 5 minutes, then normal cold start-up procedures should be followed.

5. The air flow value applies to transmitters at sea level where the air density is 1.22 kg/m^3 (0.076 lb/ft^3). At high altitudes, where the air density is reduced, the volume flow must be increased in the ratio of air density at sea level to air density at altitude in order to maintain the mass flow. See e2v technologies technical note TVB-TN01. For operation above 2286 m, contact e2v technologies.

   Cavity and electron gun cooling air must be filtered to grade BS EN779 F5 (ASHRAE efficiency >40%, <60%). This is achieved by using a secondary (or fine) filter, which may be used beneficially in series with a primary (or coarse) filter.
6. Measured at the input monitor pipe to the circuit assembly.
7. Collectors 1, 2, 3 and 4 must be cooled by good quality deionised water with a conductivity of less than 1 μS.
8. The transmitter must be able to protect the ESCIOT grid from damage in the event of an internal arc. In the event of an arc in the electron gun, the beam power must be removed from the ESCIOT to limit the energy dissipated within it to less than 20 J. This can be achieved, for example, by the use of a crowbar circuit or a solid-state, high frequency beam voltage power supply. e2v technologies is able to supply a suitable hydrogen thyratron equipped crowbar designed expressly for use with ESCIOTs. Details will be provided upon request. Users of ESCIOTs should consult their transmitter manufacturer for details of the system employed in particular equipments.
9. The high voltage power supply must be designed and connected to the ESCIOT at start-up in such a way that high voltage overshoots are minimised and do not exceed the operational maximum of 40 kV.
10. The stated minimum quiescent current is when the ESCIOT is operating in an active standby mode. The ESCIOT will not operate under full RF conditions with this quiescent current. The grid bias voltage should be adjusted to give the quiescent current in line with typical operation (see page 3) if the tube is needed for on-air service.
11. Typical operating performance will be obtained for a load VSWR of less than 1.1:1. The tube will not sustain damage for a load VSWR of less than 1.5:1.
12. The maximum voltages stated are not to be exceeded under any conditions. Under normal operation, the C_4 and C_3 collector voltages must operate within ± 1 kV of the set depression levels. During initial switch-on, the C_4 and C_3 collector voltages must be regulated to within ± 2 kV of the set depression levels.
13. Protection circuits in the transmitter must ensure that it is not possible for RF drive power to be applied to the IOT in the absence of beam voltage. Failure to do so may result in serious damage to the ESCIOT.
14. The tube can amplify either European (COFDM) or US (8-VSB) system digital signals. The typical data shown is for 8-VSB operation with a peak-to-average digital power ratio of 6.3 dB.

    Operation under COFDM conditions necessitates a much higher peak-to-average ratio, and this results in a reduction of the average power whilst maintaining the peak power at the same value as for 8-VSB.
15. At the higher channels in the UHF range, a beam voltage of up to 38 kV may be required to achieve an average digital power of 31 kW and a peak digital power of 130 kW.
16. Under RF conditions, it may be necessary to adjust the bias voltage to allow for idle current drift. Refer to section 6.4 of the ESCIOT5130W assembly manual.
17. Grid bias should be provided by a stable regulated power supply, adjustable over the range 50 to 250 V, negative with respect to cathode voltage. Adjust to provide the required quiescent current. The supply should be able to sink or source grid current, and be smoothed to better than 0.5%.
18. Intermodulation products produced by the ESCIOT under common amplifier conditions can be reduced further by suitable pre-correction circuitry in the transmitter.

    Typically, the ESCIOT will not introduce intermodulation products with an amplitude in excess of -45 dB with respect to peak sync. vision carrier when driven by a 40 IRE (250 mV) modulated ramp and single aural carrier at -10 dB with respect to peak sync. vision carrier.

19. The Figure of Merit (FOM) is calculated as:

$$\text{FOM} = \frac{P_V + P_A}{\text{beam power}} \times 100\%$$

where P_V is the peak sync. vision power, P_A is the aural power and the beam power is the beam power used when the visual signal consists of a mid-grey picture and syncs. Mid-grey is defined as the video voltage half way between black and white for the particular standard being used.

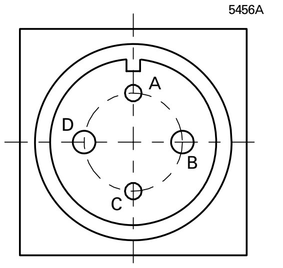
The FOM is a function of the bandwidth required from the ESCIOT output circuit. The following data are typical of FOMs for different TV standards, in common amplifier mode.

TV Standard	Bandwidth (MHz)	FOM (%)
M	6	105
G	7	100
I	8	95

View on Focus Coil Connector

Connections

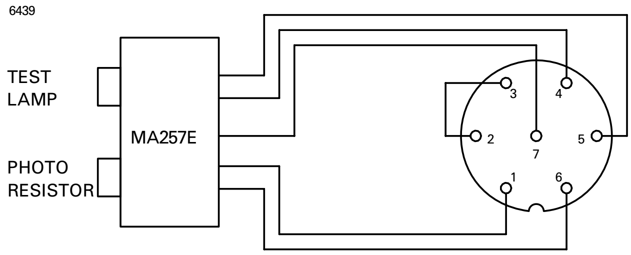
Pin	Element
A	Ejection lever (switch)
B	Focus coil positive
C	Ejection lever (switch)
D	Focus coil negative



Pins A and C are connected within the circuit assembly for use as an interlock circuit; this connection may be removed by the customer if required for other purposes, but the loss of interlock should be borne in mind.

Arc Detector Connections to socket type Amphenol T3476-001

MA257E uses a panel plug and free socket.



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US5239272	US5536992	US5548245
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US5872428	US5796322	US6407495
US5990621	US6781313	

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HEALTH AND SAFETY HAZARDS

High power IOTs can be hazardous to life and health if they are not installed, operated and maintained correctly, or if an IOT is damaged. e2v technologies does not accept responsibility for damage or injury resulting from the use of e2v technologies IOTs. Equipment manufacturers and IOT users should ensure that precautions are taken. Appropriate warning labels and notices must be provided on equipment incorporating IOTs and in operating manuals.

High Voltage

Equipment must be designed so that operators cannot come into contact with high voltage circuits. IOT enclosures should have fail-safe interlocked switches to disconnect the primary power supply and discharge all high voltage capacitors before allowing access.

RF Radiation

Personnel must not be exposed to excessive RF radiation. All RF connectors and cavities must be correctly fitted before operation, so that there is no leakage of RF energy. IOTs must not be operated without a suitable RF load at the output. It is particularly dangerous to look into open waveguide or coaxial feeders, or transmitter antennae.

X-Ray Radiation

All high voltage devices produce X-rays during operation and may require shielding. When e2v technologies IOTs are operated normally with the RF cavities fitted, some protection is provided but further shielding may be required. A suitably designed equipment cabinet will provide sufficient additional shielding. However, it is strongly recommended that all complete equipments containing operating IOT systems should be measured to establish that external X-ray levels comply with local regulations.

Mechanical

The circuit assembly has been designed to occupy the minimum of floor space in the transmitter. The wheel base is, therefore, short in relation to the height of the assembly, which has a high centre of gravity. Care is required when wheeling the magnet frame, and in particular, the IOT assembled in the magnet frame, over uneven surfaces or gradients which could cause the assembly to overbalance.

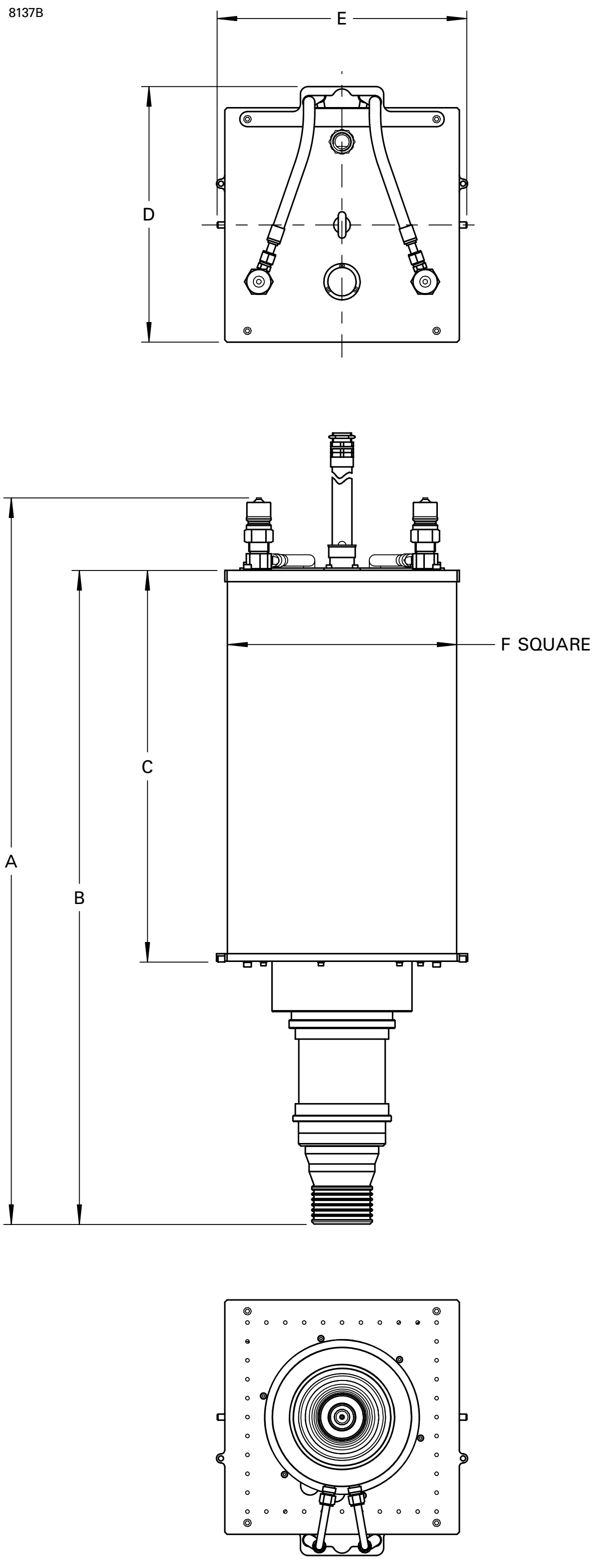
Hot Surfaces

Surfaces of tubes (for example the tube envelope in the gun region and the collector manifold in an air-cooled tube) can reach high temperatures (in some cases in excess of 100 °C) during operation and may remain at a high temperature for a considerable time after switch-off. Burns may be sustained if direct contact is made with hot surfaces.

Toxic

IOTs and ESCIOTs all contain industry standard cathode assemblies as part of the electron gun. The cathode assembly contains small quantities of various refractory metals. In normal operation, the presence of these materials requires no special precautions as they are sealed in vacuum. However, in the event of a catastrophic tube failure, resulting in loss of vacuum and exposure of a hot cathode to the atmosphere, these metals can form volatile oxides that are potentially hazardous to health. In such circumstances, operators should avoid inhaling vapours in close proximity to the tube and allow it to cool to room temperature before removing it from equipment. Broken tubes should be repacked carefully in their original packaging and returned to e2v technologies for safe disposal.

OUTLINE OF ESCIOT5130W
(All dimensions nominal)



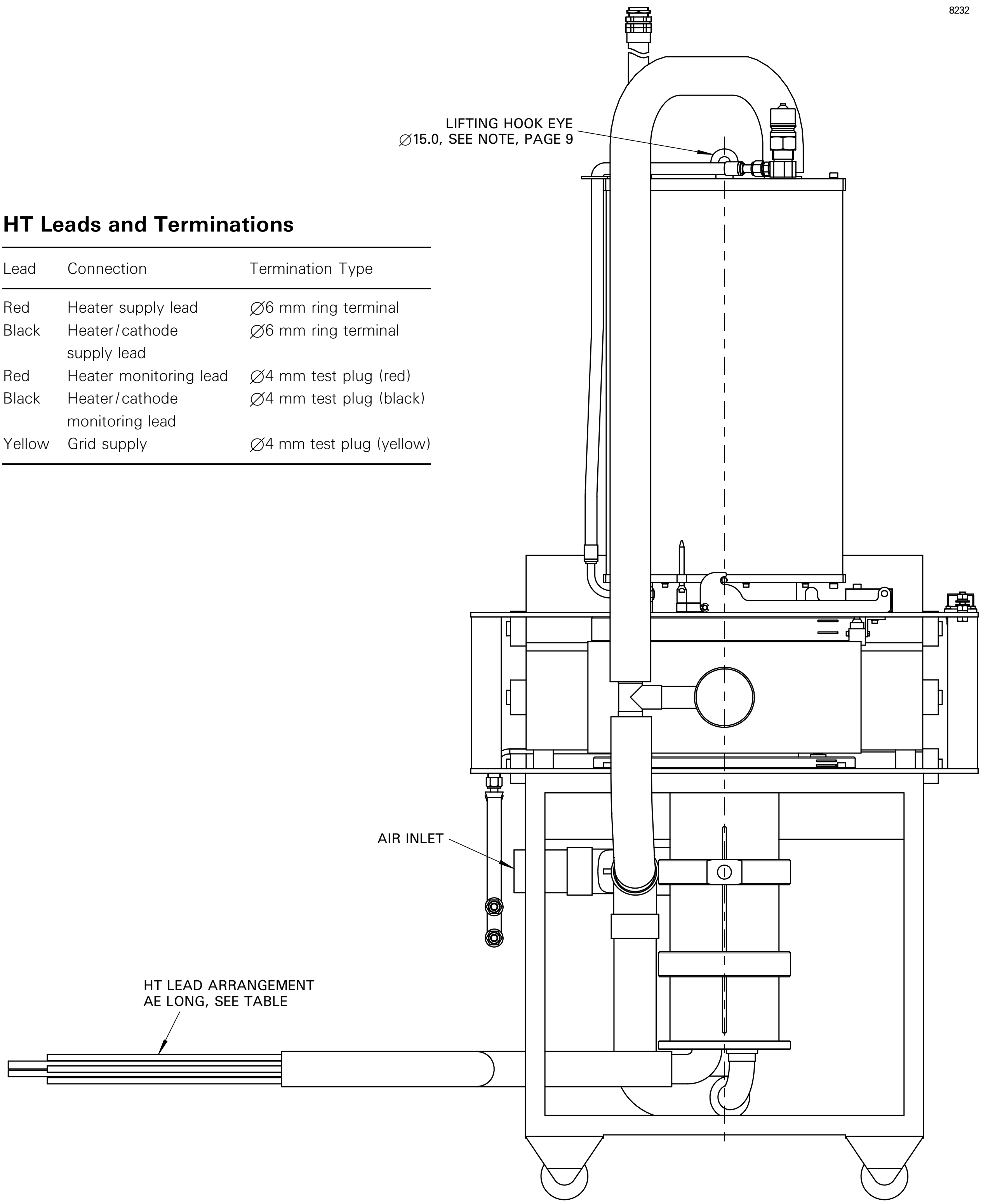
Ref	Millimetres	Inches
A	961.0	37.835
B	865.0	34.055
C	517.0	20.354
D	338.0	13.307
E	332.0	13.071
F	303.0	11.929

Inch dimensions have been derived from millimetres.

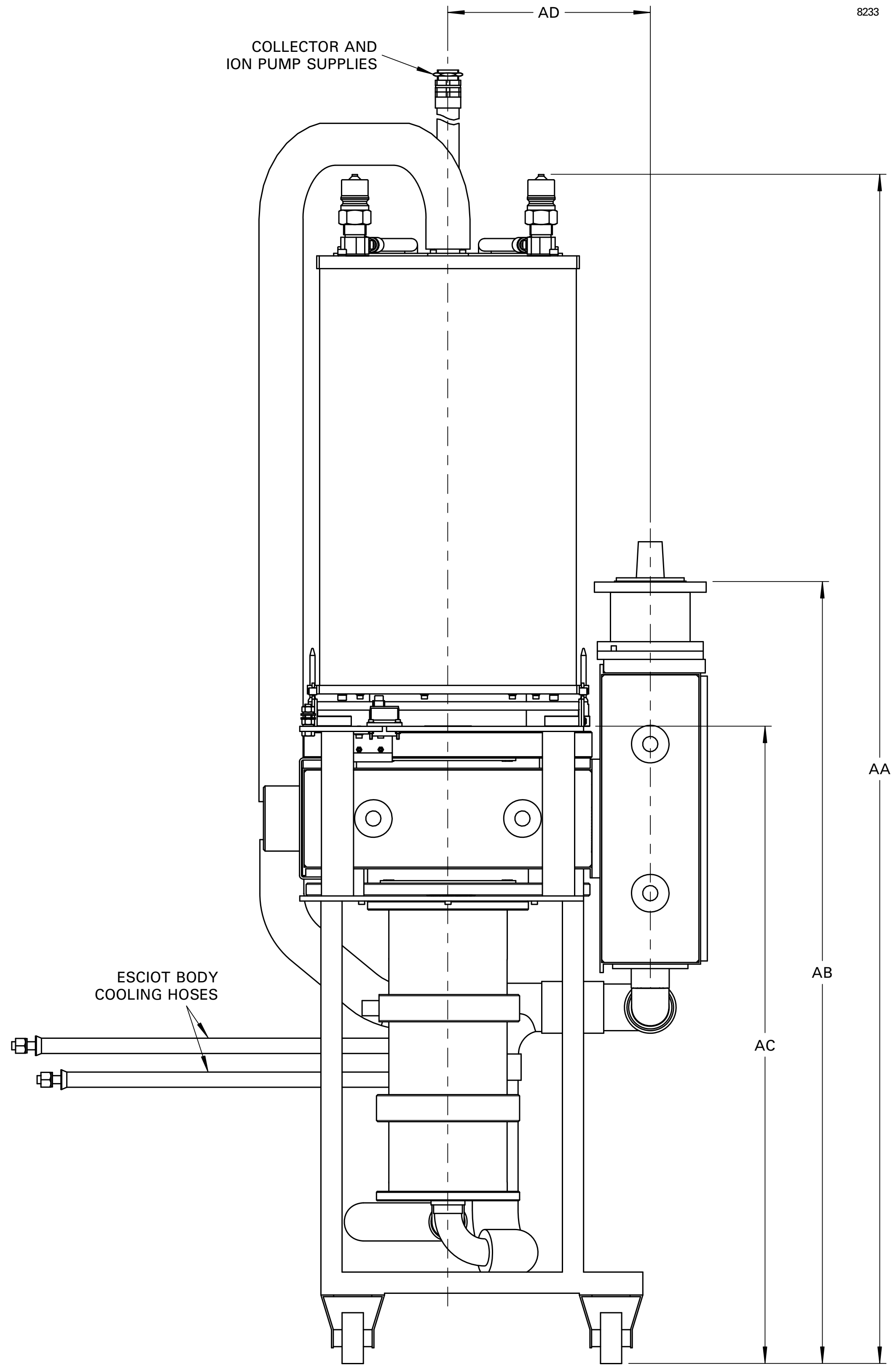
OUTLINE OF CIRCUIT ASSEMBLY
(All dimensions nominal)

HT Leads and Terminations

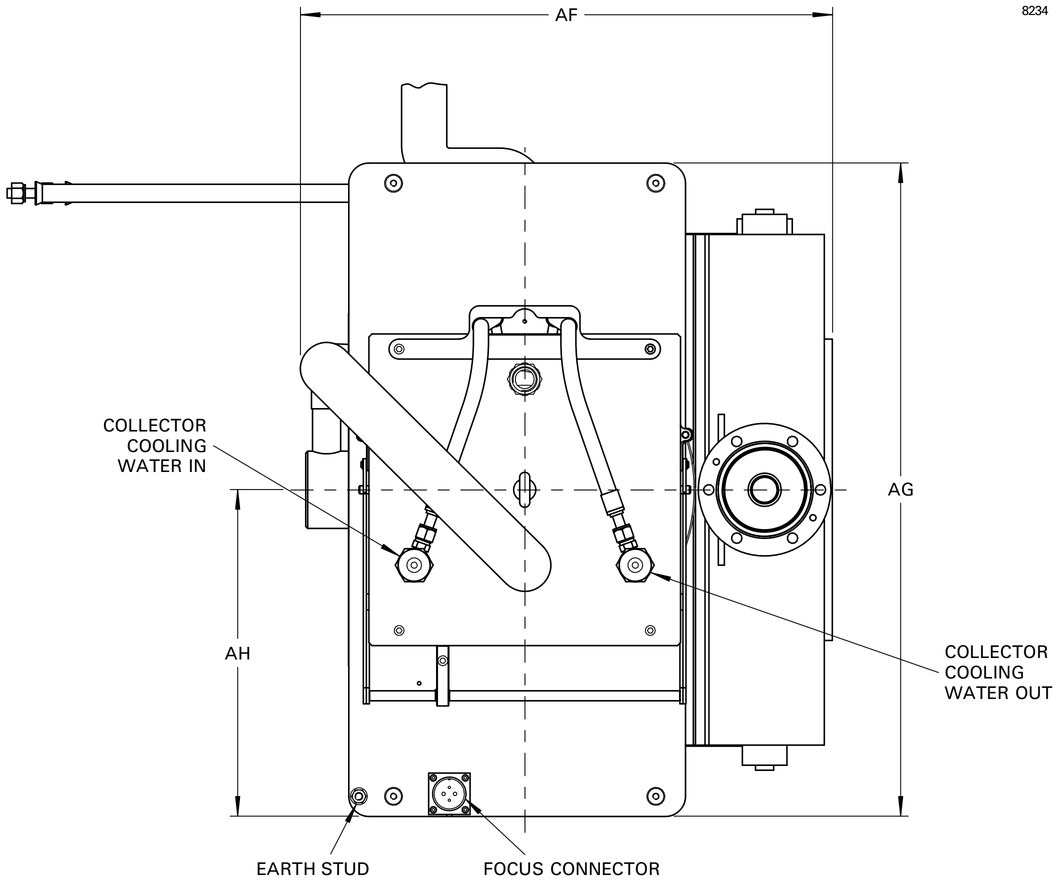
Lead	Connection	Termination Type
Red	Heater supply lead	∅6 mm ring terminal
Black	Heater/cathode supply lead	∅6 mm ring terminal
Red	Heater monitoring lead	∅4 mm test plug (red)
Black	Heater/cathode monitoring lead	∅4 mm test plug (black)
Yellow	Grid supply	∅4 mm test plug (yellow)



SIDE VIEW OF CIRCUIT ASSEMBLY



TOP VIEW OF CIRCUIT ASSEMBLY



Ref	Millimetres	Inches
AA	1403.0	55.236
AB	923.0	36.339
AC	752.0	29.606
AD	239.0	9.409
AE	1000.0	39.370
AF	529.0	20.827
AG	650.0	25.591
AH	325.0	12.795

Inch dimensions have been derived from millimetres.

Outline Note – Lifting

A minimum clearance of 1758 mm (69.213 inches) is required when lifting the tube out of the circuit assembly.