

E2V Technologies IOTD140R IOT Amplifier For Digital UHF Television Service

FEATURING

- **Frequency Range** 470 to 860 MHz in a single tube and circuit.
- **Output Power** Rated as a digital amplifier for up to 42 kW peak power and 10.5 kW average power.
- **Long Life** High reliability electron gun with impregnated dispenser cathode and pyrolytic graphite grid.
- **Simple, Efficient Cooling** The cavities, the electron gun, the body and the collector are forced-air cooled.
- **Simple Tube Exchange** Continuously tunable external output cavities, with digital frequency indicators. This means that a replacement tube will be coarse tuned on installation, needing only trimming adjustments.
- **Easy to Tune Input Cavity** Input cavity has two controls, one for tuning and one for impedance matching.
- **All Ceramics Aluminium Oxide** No beryllium oxide hazard.

DESCRIPTION

IOTD140R is a high efficiency Inductive Output Tube amplifier for use in the output stages of digital transmitters in UHF television service.

The IOT has an electromagnetically focused electron beam which is density bunched using a rugged grid driven by an RF cavity. The IOT beam power varies with the depth of modulation.

The circuit assembly is designed to reduce tube replacement time to a minimum. The tube can be detached from the output cavity system and a replacement fitted without disturbing the tuning, so that the replacement IOT is coarse tuned at switch-on and requires only trimming adjustments. A digital indication of the output cavity frequency is provided.

The electron gun, cavities and collector 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 air outlet is at the top of the assembly.

ABRIDGED DATA

Frequency range	470 to 860	MHz
Peak output power at IOT flange	42	kW
Average output power	10.5	kW
Gain (minimum)	20	dB
Beam voltage	26	kV



DIGITAL

GENERAL

Electrical

Cathode	indirectly heated
Heater voltage (see note 1)	9.0 to 10.0 V dc
Heater current range	9.0 to 11.0 A
Cathode pre-heating time	5 minutes
Ion pump to ground voltage	+3.0 to 4.0 kV
Internal impedance of ion pump supply	500 k Ω approx

Mechanical (IOTD140R tube)

Overall length	814.5 mm (32.067 inches) nom
Overall width	320 mm (12.598 inches) nom
Mounting position	vertical, collector end up
Net weight of IOT	20 kg (44 pounds) approx

Circuit Assembly IMD140R

Electromagnet voltage	4 to 6 V
Electromagnet current	20 to 25 A
RF input connector	type N coaxial (male)
RF output	3 1/8 inch 50 Ω coaxial line
Net weight	110 kg (243 pounds) approx

Cooling

Air flow to cavities and cathode terminal (see notes 2 and 3)	3.0 m ³ /min	100 cfm
Static pressure head (see note 4)	1.27 kPa	5.0 inches w.g.
Minimum air flow to collector (see note 5)	25 m ³ /min	875 cfm
Static pressure head (see note 4)	1.27 kPa	5.0 inches w.g.
Inlet air temperature	60 $^{\circ}$ C max	
Outlet air temperature	130 $^{\circ}$ 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	NSL 462
Minimum dark resistance	20 M Ω
Resistance at 1 foot-candle	28 k Ω
Resistance at 100 foot-candles	600 Ω
Maximum voltage (peak)	70 V
Maximum temperature	75 $^{\circ}$ C
Layer	cadmium sulphide
Test lamp	28 V
	0.04 A
Connections	see page 4

MAXIMUM RATINGS (Absolute values)

The transmitter must be provided with a fast disconnect circuit which operates in the event of an internal arc (see note 6). 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)	20 A
Beam voltage (see note 7)	30 kV
Quiescent current	800 mA
minimum	100 mA
Collector dissipation	25 kW
Load VSWR (see note 8)	1.5:1
Temperature of any part of	
tube envelope	150 $^{\circ}$ C
Collector core temperature	250 $^{\circ}$ C
Peak drive power (see note 9)	500 W
Average drive power	150 W
Grid to cathode bias voltage	-200 V dc
Grid current	\pm 150 mA
Ion pump current (beam on)	20 μ A
Peak output power	45 kW
Average output power	12 kW
X-ray radiation	2 μ Sv/hr
Altitude	3658 m
	12 000 ft

TYPICAL OPERATION

Digital Amplifier Service

Beam voltage	26 kV
Heater voltage	9.5 V
Peak output power	42 kW
Average output power	10.5 kW
Quiescent beam current	0.4 A
Grid bias voltage with respect to	
cathode voltage	see note 10
Beam current	0.9 A
Peak drive power	300 W
Average drive power	70 W

NOTES

- The polarity of the heater supply must be such that the heater is always negative with respect to the cathode.

The actual heater voltage to be used on a particular IOTD140R is advised with the tube.

Passive Standby and Quick-Start Modes

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

Background Heat Passive Standby Mode

The IOTD140R must be operated with a Background Heat filament voltage of 8.0 V.

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

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 IOT 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, 5-minute, 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 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 IOT 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 IOT 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.

Alternatively, the quiescent current may be maintained at the normal operational level, with no adverse effects to the IOT, but with slightly reduced overall system efficiency resulting from greater standby power dissipation.

Mains Interruptions

If mains power is absent for a time less than or equal to 15 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 a time between 15 seconds and five minutes, then heater voltage should be re-applied for a time equal to the mains absence time before attempting to re-power the IOT, which should then be powered in the normal way.

If mains power is absent for a time in excess of five minutes, then normal cold start-up procedures should be followed.

2. This 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 significantly 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.
3. 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.
Collector air must be filtered to grade BS EN779 G1 (ASHRAE arrestance $<65\%$). This is achieved by using a primary (or coarse) filter.
4. Measured by a manometer at the input pipe to the circuit assembly.
5. The IOT should be interlocked such that the output signal of the temperature sensor circuit triggers the removal of HT and RF drive in less than 100 ms in the event of the collector temperature exceeding 250°C .
6. The transmitter must be able to protect both the IOT and itself from damage in the event of an internal arc within the IOT. In such an event, the beam power must be removed from the IOT 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 gas discharge tube equipped crowbar designed expressly for use with IOTs. Details will be provided upon request. Users of IOTs should consult their transmitter manufacturer for details of the system employed in particular equipments.
7. The high voltage power supply must be designed and connected to the IOT at start-up in such a way that high voltage overshoots are minimised and do not exceed the stated maximum.
8. 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.
9. 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 IOT.
10. Grid bias should be provided by a regulated power supply, adjustable over the range 25 to 150 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.

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 and intermediate cavities. 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

Care is required when lifting the circuit assembly and the IOT into the transmitter cubicle. Protective footwear should be worn.



Hot Surfaces

Surfaces of tubes (for example the tube envelope in the gun region and the collector manifold) 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.

INTELLECTUAL PROPERTY RIGHTS

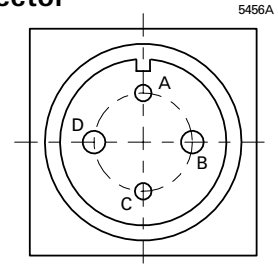
This product is subject to one or more of the following US patents and corresponding patents in other countries:

US4728860	US5239272	US5536992
US5548245	US5581153	US5606221
US5629582	US5691667	

View on Focus Coil Connector

Connections

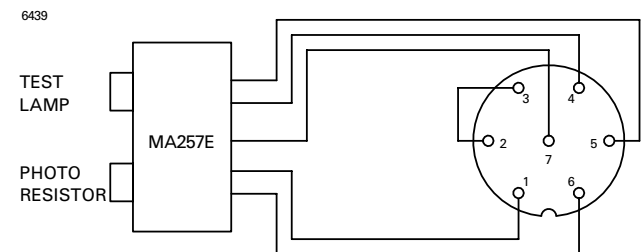
Pin	Element
A	Interlock
B	Focus coil positive
C	Interlock
D	Focus coil negative



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

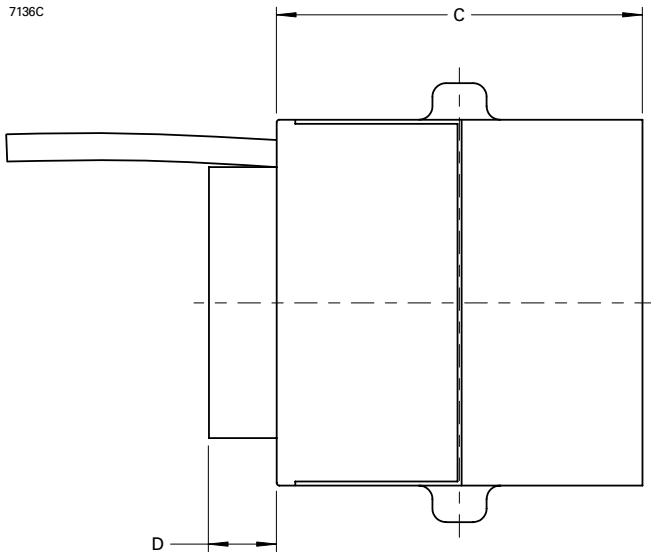
MA257E uses a panel plug and free socket.



OUTLINE OF IOTD140R

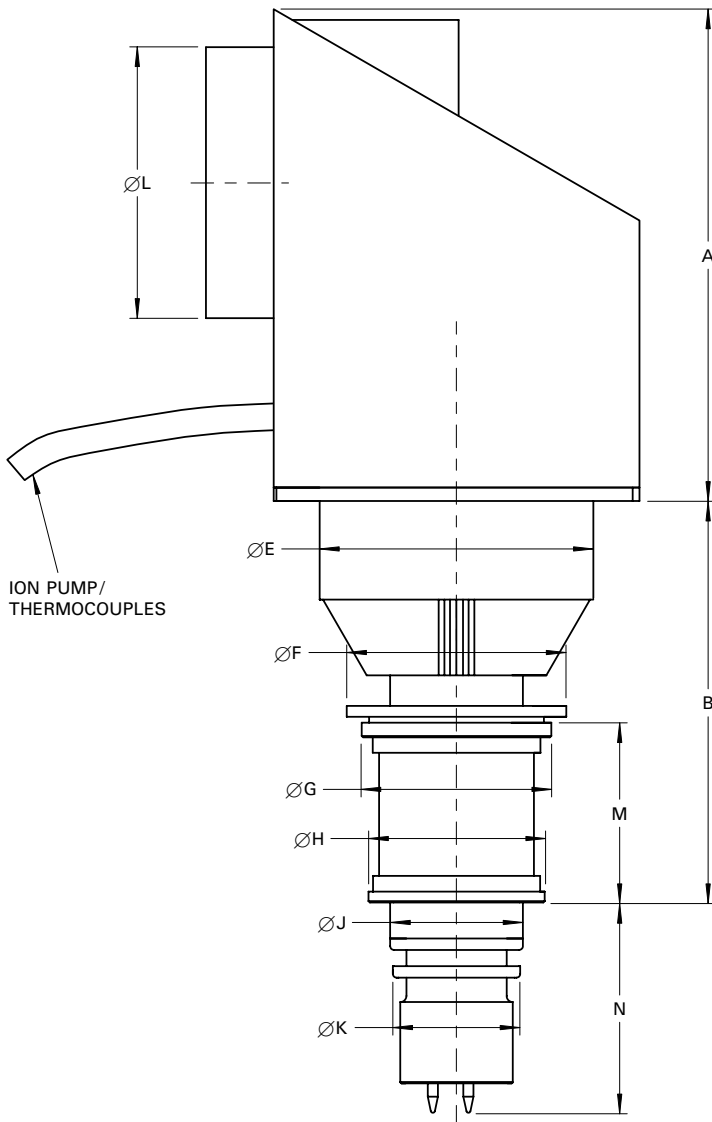
(All dimensions nominal)

7136C

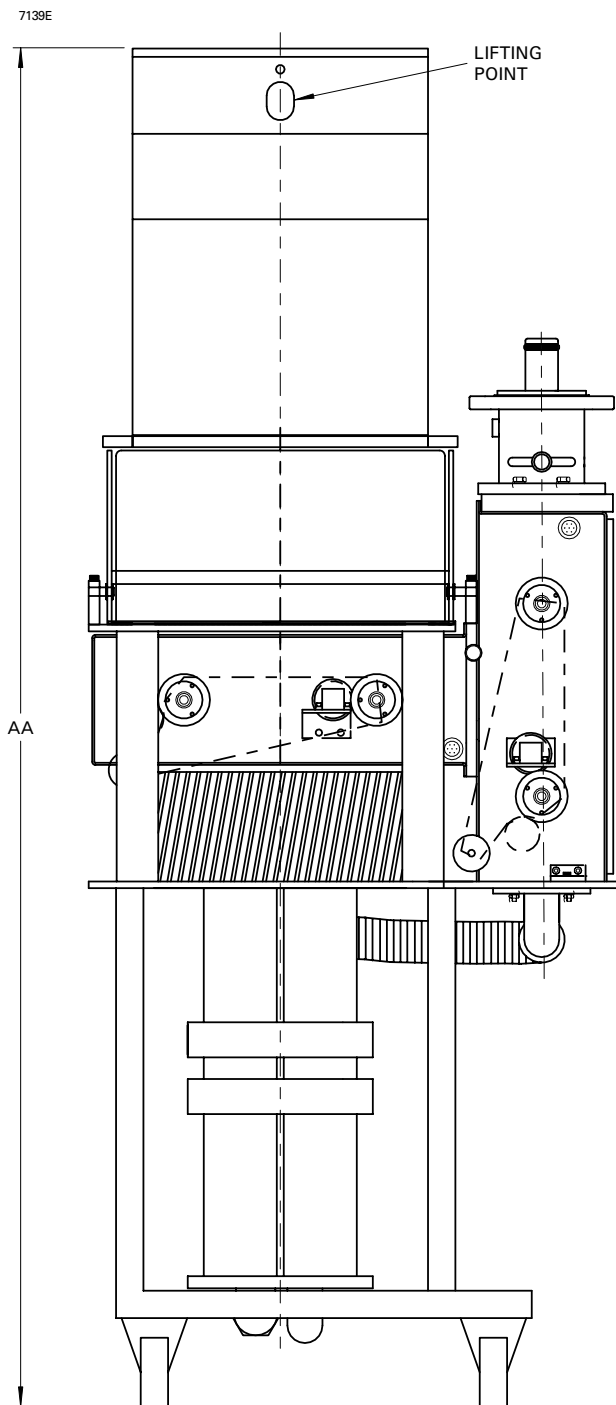


Ref	Millimetres	Inches
A	363.0	14.291
B	296.25	11.663
C	270.0	10.630
D	50.0	1.969
E	202.0	7.953
F	162.0	6.378
G	140.0	5.512
H	130.0	5.118
J	98.0	3.858
K	94.0	3.701
L	200.0	7.874
M	132.5	5.217
N	155.25	6.112

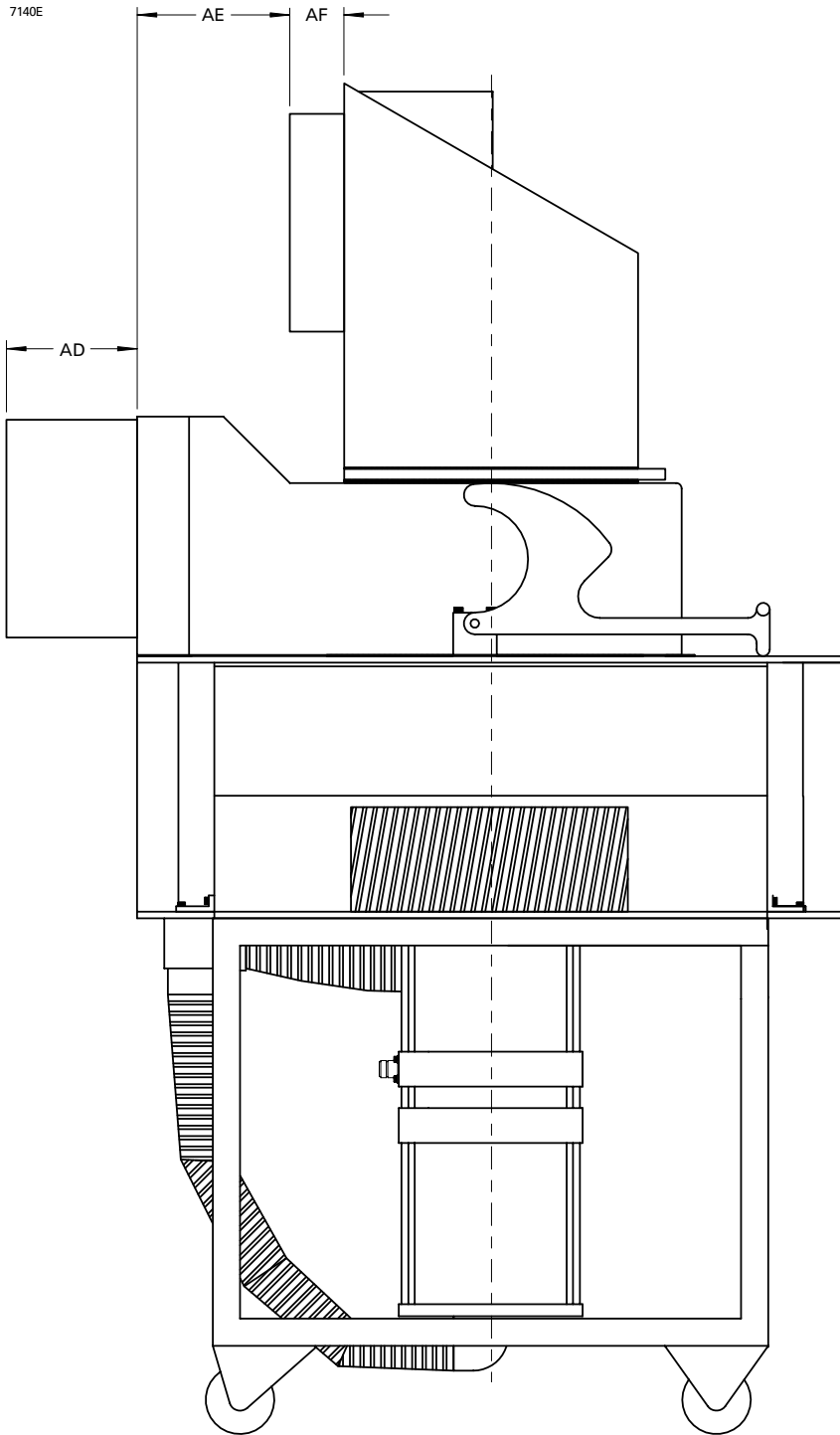
Inch dimensions have been derived from millimetres.



OUTLINE OF CIRCUIT ASSEMBLY IMD140R (All dimensions nominal)

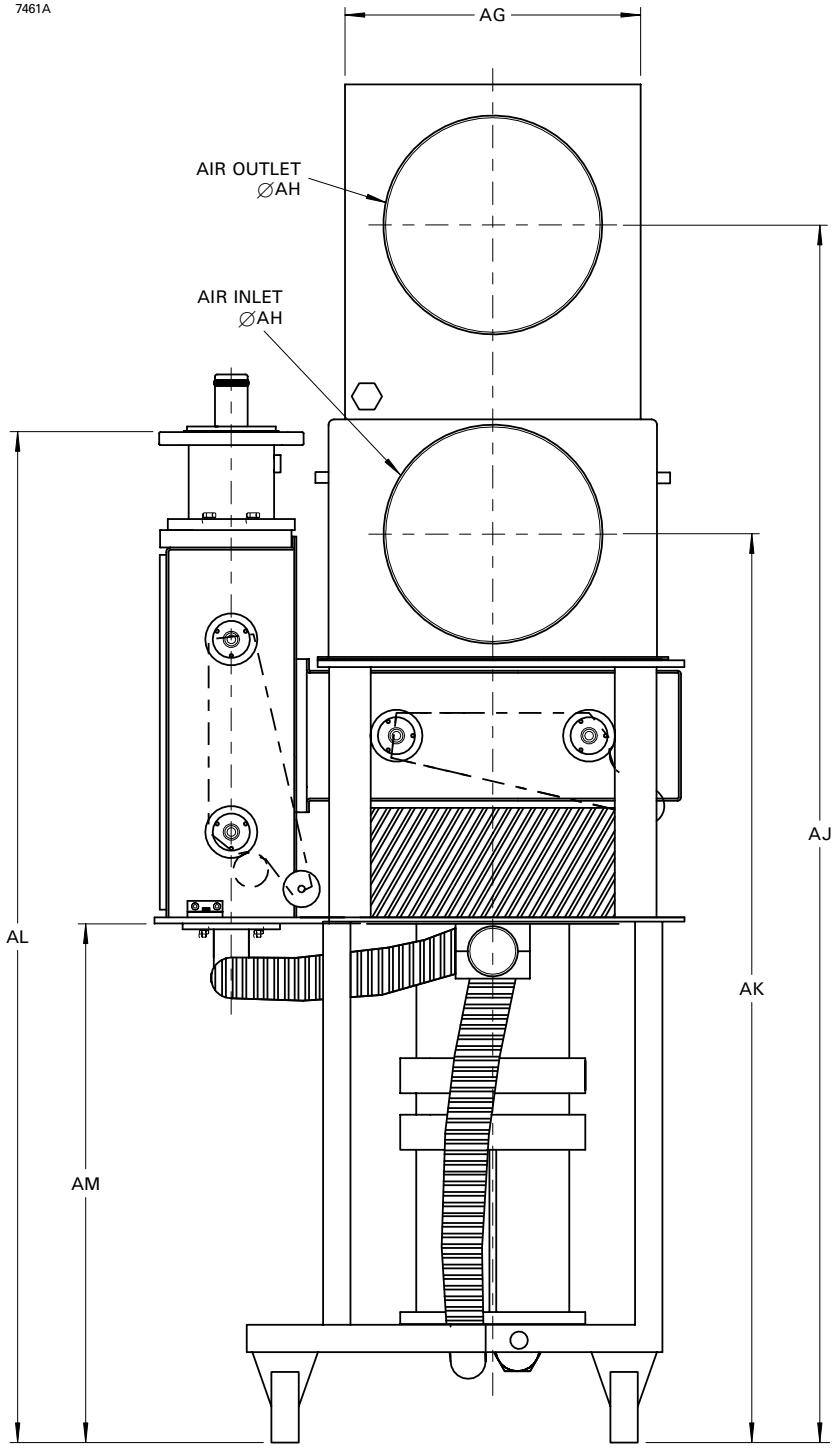


SIDE VIEW OF CIRCUIT ASSEMBLY

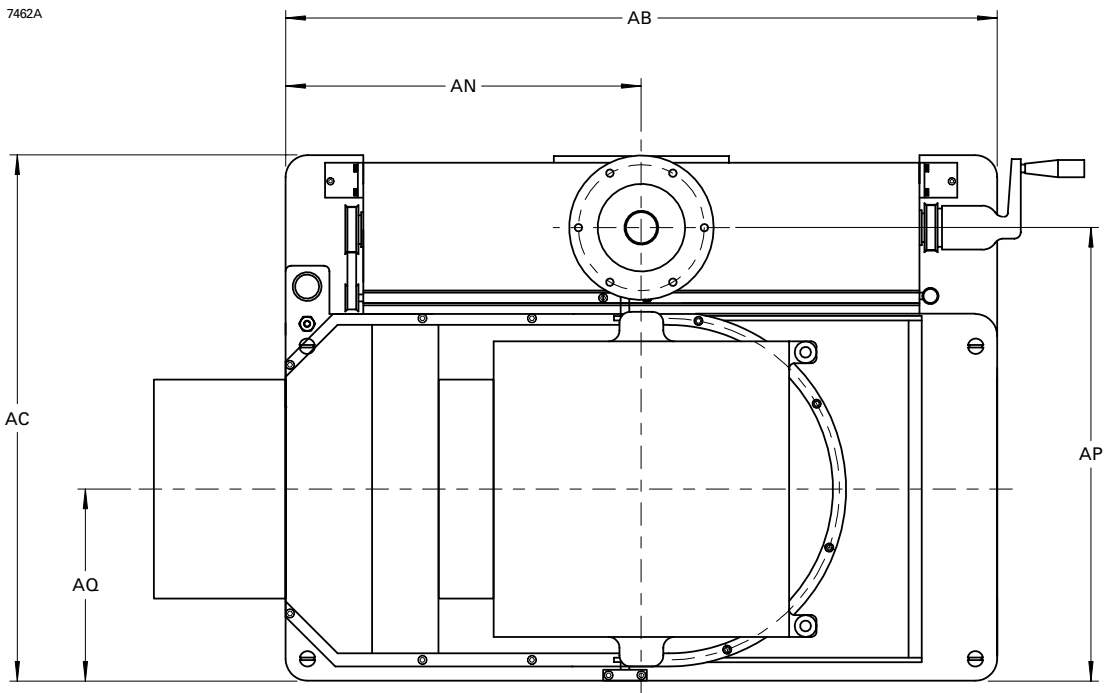


REAR VIEW OF CIRCUIT ASSEMBLY

7461A



TOP VIEW OF CIRCUIT ASSEMBLY



Ref	Millimetres	Inches
AA	1240.5	48.839
AB	650.0	25.591
AC	480.0	18.898
AD	120.0	4.724
AE	140.0	5.512
AF	50.0	1.969
AG	270.0	10.630
AH	200.0	7.874
AJ	1112.0	43.780
AK	830.0	32.677
AL	923.0	36.339
AM	474.0	18.661
AN	325.0	12.795
AP	414.0	16.299
AQ	175.0	6.890

Inch dimensions have been derived from millimetres.

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