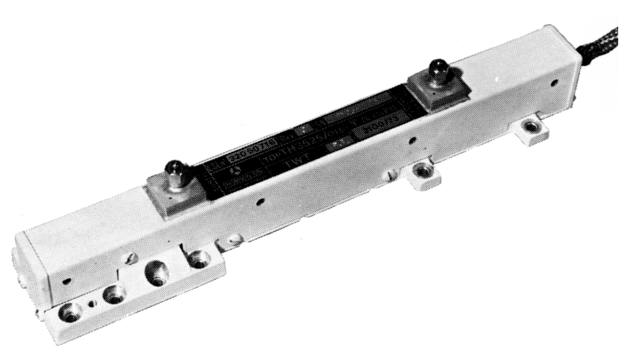
THOMSON-CSF
DIVISION TUBES ELECTRONIQUES

TH 3525

HIGH-EFFICIENCY 11-12 GHz TWT FOR COMMUNICATIONS SATELLITES

FEATURES



- **Specifically developed for use in communications-satellite transponders.**
- **Exceptional efficiency**, due to a two-stage collector. A minimum overall tube efficiency of 40 % is guaranteed.
- **Stable thermal dissipation**, regardless of drive level, also thanks to the two-stage collector.
- **High gain** : at least 55 dB at saturation and over 60 dB under small-signal conditions.
- **Powerful** : over 20 watts of saturated output power available.
- **Linear transmission characteristics** : small-signal to saturation phase shift limited to 40°.
- **Lighweight, compact, and extremely rugged**, to withstand all the rigors of launching and the space environment .
- **Extremely reliable** : designed to operate at least seven full years in space, with an MTTF of at least 500000 hours. Long life impregnated-tungsten cathode.

DESCRIPTION

The TH 3525 high-gain, high-efficiency traveling-wave tube has been developed to meet the exacting requirements of in-space operation in communications-satellite transponders. Delivering more than 20 watts of output power at saturation, in the 10.95 - 11.70 GHz frequency band (1), this lightweight, compact tube is rugged enough to withstand the severe environmental conditions encountered in launching, orbital insertion and operation in space,

A two-stage collector is used to enable recovery of most of the residual beam energy, thus significantly increasing the tube's efficiency, up to a typical 43 %, and greatly reducing primary-power consumption. Simultaneously, this collector solves another major problem for communications-satellite designers, by making the thermal dissipation essentially independent of the RF input level.

The TH 3525 also features the very small fine-grain small-signal gain variations and flat gain characteristics needed in satellite-transponder service.

Since a TWT in this application must normally perform simultaneous amplification of several carriers, the linearity of its transmission characteristics is extremely important. This is expressed by the setting of a limit value for the phase variation between small-signal and large-signal operation. In ordinary TWT's, optimizing the efficiency and the phase characteristics at the same time is not possible. By using a tapered helix in the TH 3525, though, the total phase shift has been held to a maximum of 40°, while the operating efficiency has been raised to at least 40 %, guaranteed. At the same time, none of the tube's other electrical characteristics have been degraded, as compared to a non-tapered-helix tube.

(1) - The band allocated for the European satellite-communications system.

Featuring PPM focusing, this tube is cooled by simple conduction alone, through its baseplate.

Having completed qualification for the European Space Research Organization (ESRO), the TH 3525 is manufactured to the very strict quality-assurance standards for spaces tubes, and is designed to provide at least seven years of continuous in-space operation. It is estimated that the improved impregnated-tungsten cathode will have a useful operating life of more than 200 000 hours.

Variants of this TWT are available for operation in other frequency ranges and/or at lower power levels. The Electron Tube Division of THOMSON-CSF welcomes the opportunity to discuss your specific requirements with you.

SPECIFICATIONS

Performance

Frequency range (Note 2)	10. 95 to 11. 70 GHz
Single-carrier saturated output power, min.	13 dBW (20 W)
Saturation gain, min.	55 dB
Overall electrical efficiency, min.	40 %
Small-signal gain, min.	60 dB
Noise figure, max.	27 dB
Frequency response (in any 125-MHz channel)	
Gain ripple, max. at saturation	± 0. 1 dB
Gain ripple, max. small-signal	± 0. 2 dB
Gain slope, max. at saturation	± 0. 005 dB/MHz
Gain slope, max. small-signal	± 0. 01 dB/MHz
Third-order intermodulation products	
With 2 equal-amplitude carriers driving the TWT to saturation	< – 10 dB, relative to either carrier's output level
With each carrier output at a level, relative to single carrier saturation level, of	– 6 dB – 9 dB – 13 dB
the 3rd-order IM product's level, relative to either carrier is	– 17 dB – 24 dB – 33 dB
AM/PM Transfer	
Two carriers driving the TWT to saturation	⩽ 4. 5°/dB
Below saturation	⩽ 6°/dB
AM/PM Conversion, all input levels up to saturation	6°/dB
Small-signal to saturation phase shift, max.	40 °
Group delay variation at saturation, max.	0. 5 ns
Total harmonic power, relative to the single carrier saturation level, max.	– 15 dB

Normal load operation : TWT meets all specifications when operating into a load having an in-band VSWR of 1. 1 : 1, max.

Mismatch operation : TWT can stand up to 24 hours of operation into a load with a 2. 5 : 1 VSWR.

Overdrive operation : TWT can operate up to 24 hours with an input 10 dB above saturation drive, without switchoff.

(2) The 10. 95 - 11. 70 GHz range has been allocated to Europe for satellite communications. Other frequency ranges and/or lower output levels are quite envisageable.

Mechanical

Weight, approx.	650 g
Dimensions	See the Outline Drawing
RF connections	Female SMA type
Power supply connection	Flying leads or other termination on request
Cooling	By conduction
Operating temperature range (baseplate)	
- Normal	– 5° C to + 70° C
- Extreme	– 15° C to + 85° C
Thermal flux (TWT to baseplate)	$\leqslant$ 1. 5 W/cm^2
Ambient pressure for satisfactory operation	>500 mm Hg or < 10^{-4} mm Hg

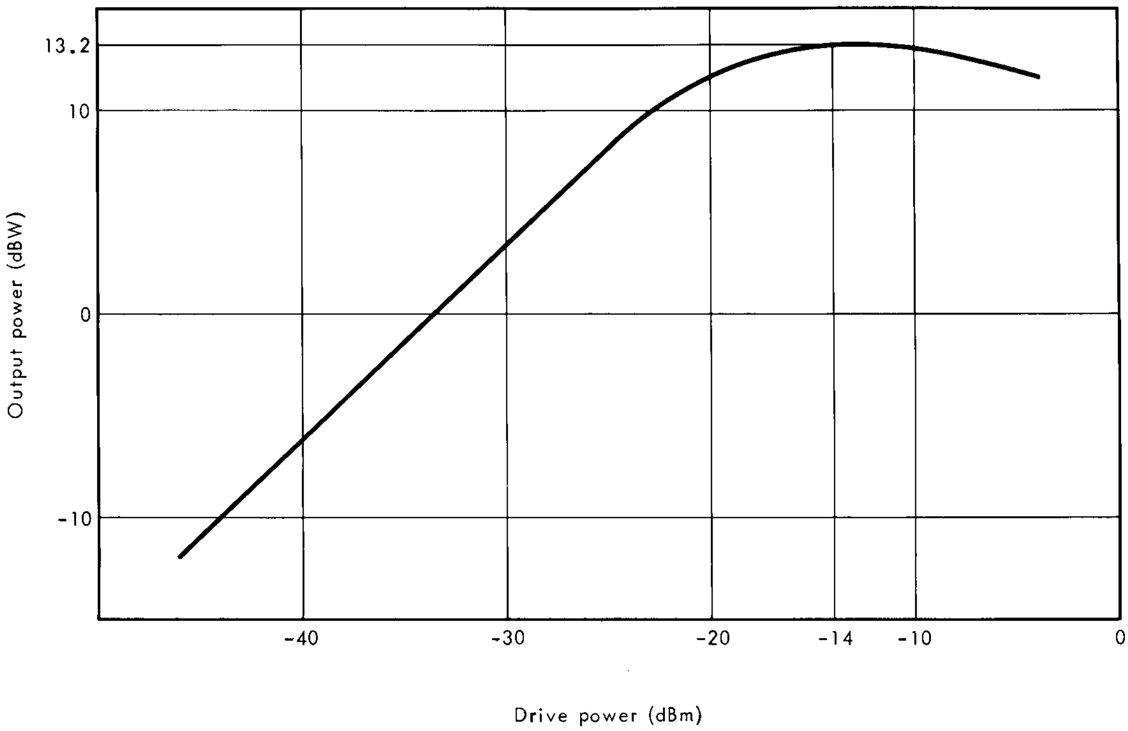
TYPICAL OPERATION

Single-carrier saturated output power	+ 13. 2 dBW
Saturated gain	57 dB
Small-signal gain	62 dB
Noise figure	26 dB
VSWR input and output	As specified
Frequency response	As specified
Third-order intermodulation products	As specified
AM/PM Transfer and conversion	As specified

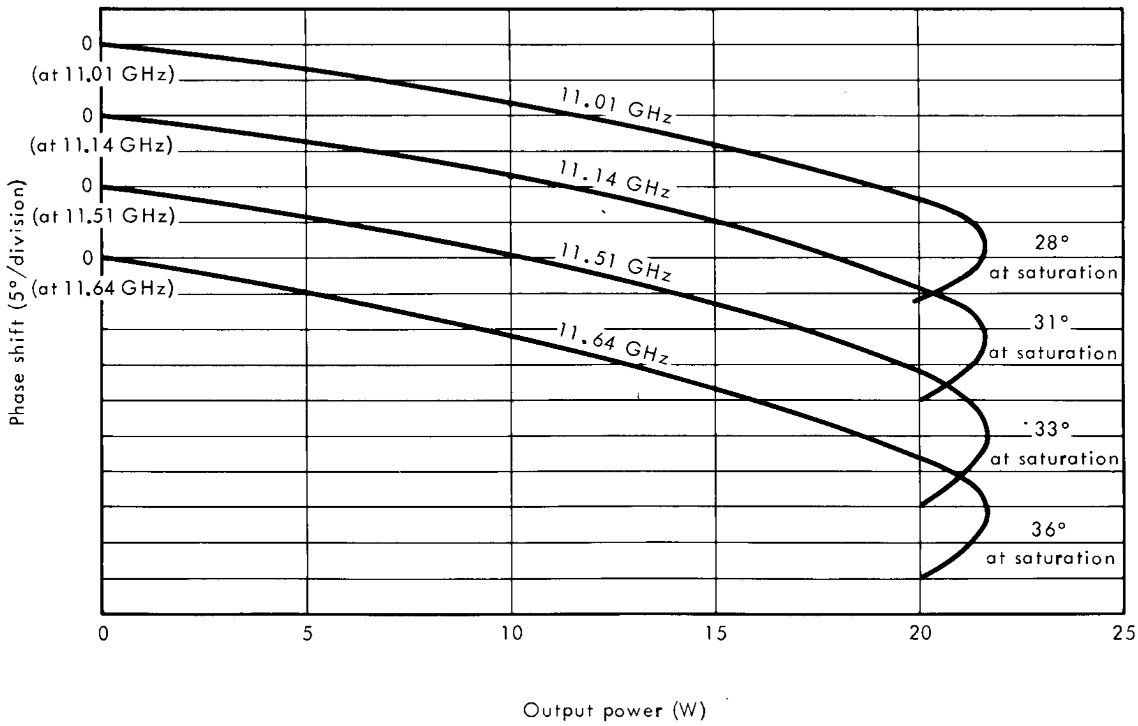
Output level below saturation	0 dB	– 3 dB	– 6 dB	– 10 dB
Phase shift at 11. 7 GHz	36°	12°	6°	3°

Variation of group delay	As specified
Harmonic power	As specified

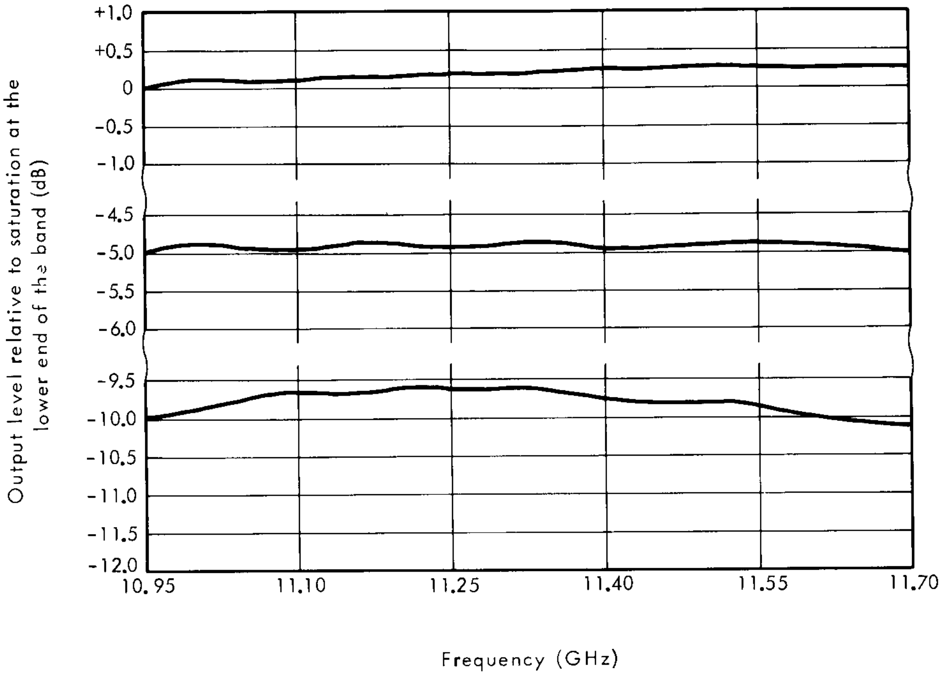
OUTPUT POWER VERSUS DRIVE POWER



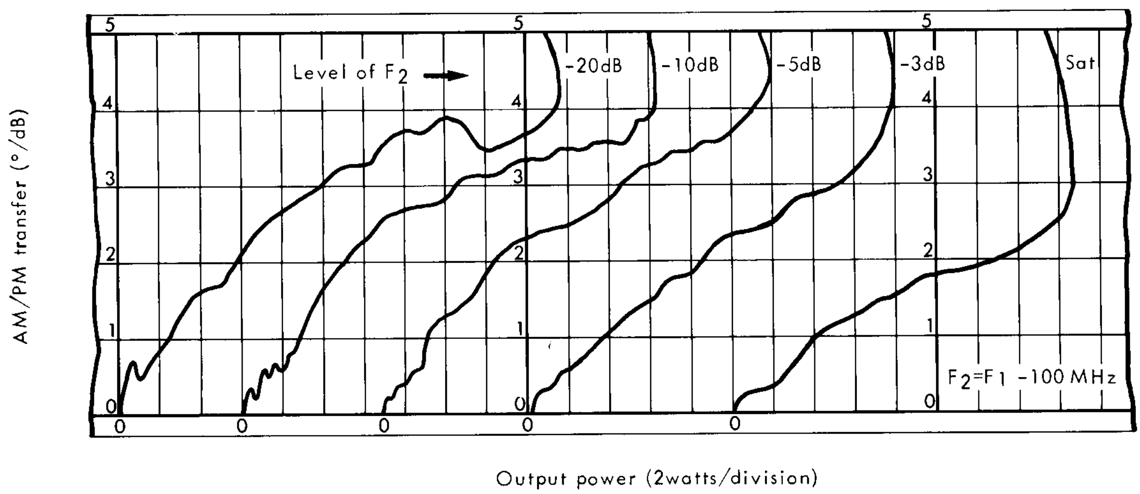
PHASE SHIFT VERSUS OUTPUT POWER
(Typical curves)



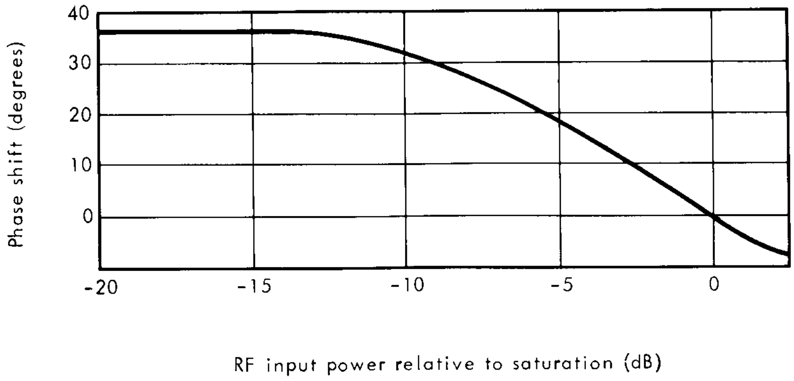
GAIN FLATNESS VERSUS FREQUENCY



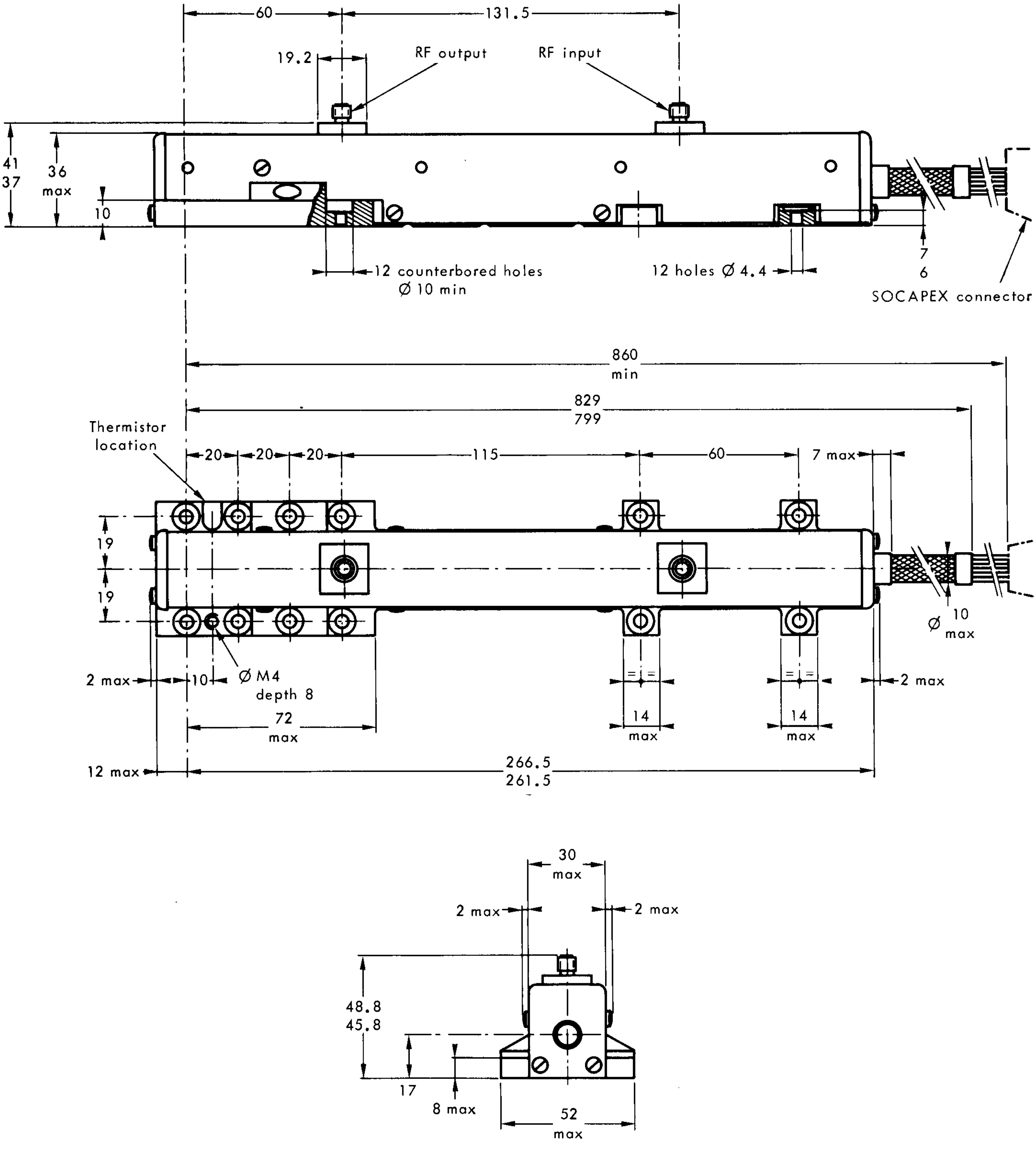
AM/PM TRANSFER VERSUS OUTPUT POWER
(level of F_1 held constant while level of F_2 is varied)



PHASE SHIFT VERSUS RF DRIVE
(Typical)



OUTLINE DRAWING



Dimensions in mm, nominal unless otherwise marked.