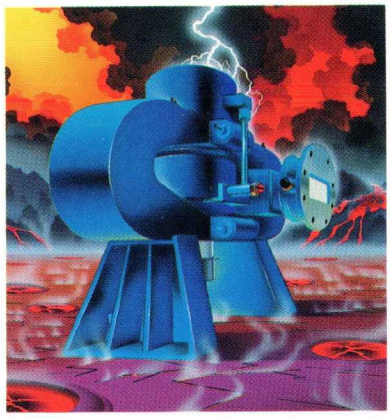
# Discover the power of CFAs.



*Crossed-field amplifier tubes are high power, broadband microwave amplifiers using the unique interactive characteristics of traveling wave circuits and density modulated electron beams. These electron beams move perpendicular to the magnetic field lines to generate output signals of high power over broad frequency bandwidths with unusually good efficiency and phase coherency. Their low operating voltages and compact size make CFAs attractive for mobile, airborne and distributed phased array radar applications.*

# Litton's 25 years of CFA experience.

Since the early 1960s Litton Electron Devices has been engaged in the development of pulsed and CW crossed-field amplifier tubes.

Early efforts at Litton led to the development of the Distributed Emission Magnetron Amplifier (DEMATRON). This product was designed for radar applications where pulse burst modes, pulse-to-pulse repetition rate changes or variable pulse widths were required.

Litton also developed CFAs that employed a cold cathode for instantaneous turn-on. Reentrant and non-reentrant beam designs were produced using this cold cathode in S, C and X-bands with peak power outputs of 200 kW to 2.6 MW. These tubes provided moderate gains of 14-20 dB and typical instantaneous bandwidths of 10-15%.

In the early 1980s all the CFA work was transferred to the Williamsport, Pennsylvania facility. The reentrant beam forward-wave CFA development effort resulted in the first Litton prototype designs for the AEGIS phased array radar. This tube has now been put into full production.

**A broad CFA product line**

Today, Litton offers a full range of CFAs. Production quantities are available at low and high peak power output in either forward-wave or backward-wave formats.

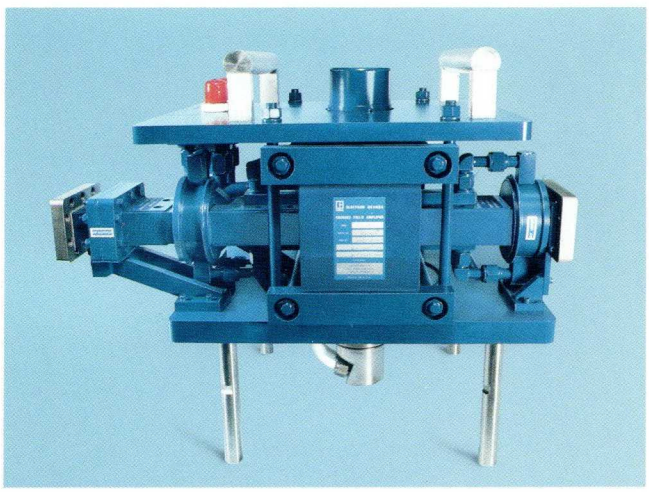
Litton manufactures crossed-field amplifiers with bandwidths of over 17% and gains on the order of 20 dB at high peak power levels in various frequency bands. Litton CFAs feature liquid-cooled platinum cathodes that improve spurious noise and extend life expectancy beyond 5,000 hours, and in some cases, beyond 10,000 hours.

Litton CFAs are employed in a wide range of high performance airborne and surface radars where phase stability, pulse compression and MTI are required. Lightweight, high-gain designs are also in development for the newest sophisticated missile systems.

# Pushing the frontiers of CFA performance.

Over the past six years Litton Electron Devices has invested substantially in the development of a total crossed-field amplifier capability.

Litton pulled together the industry's most experienced team of CFA engineers and backed their efforts with major investments in plant, equipment and personnel. As a result of this Litton investment the state of the art for CFAs has been significantly advanced.



The L-4719. An S-band CFA offering wide range duty cycle capability and up to 2.2 MW peak power.

**Improved cathodes.** Litton CFAs are designed primarily with liquid-cooled platinum cathodes. These Litton cathodes are characterized by long life and stable performance, and are almost entirely free from arcing.

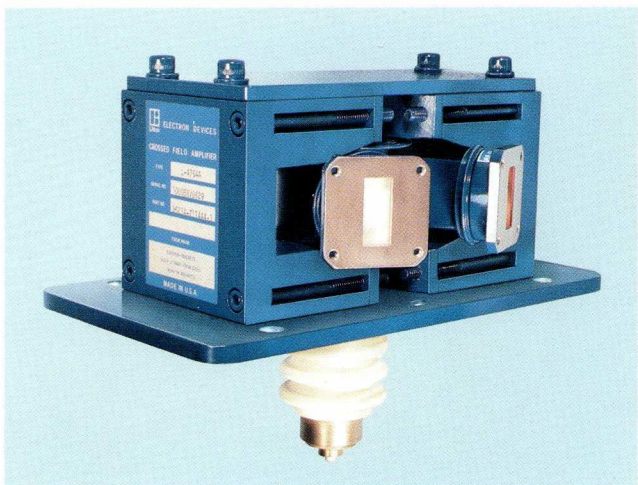
**Higher gain.** A decade ago the typical gain expected of any pulsed CFA was on the order of 8 to 10 dB. Today, better material processing techniques and improved circuit design allow Litton to produce CFAs like the L-4767. This forward-wave tube is capable of 20 dB gain.

**Greater stability and efficiency.** Litton has improved electronic efficiency through tighter coupling between the slow-wave structure and the external load. This also reduces the RF voltage present in the interaction region and substantially improves pulse stability.

**Further improvements still to come.** Impressive as these advances are, they have yet to exhaust the possibilities of CFA performance. Litton has already achieved efficiencies of 60% to 70% in production tubes.

Noise performance will improve, too. Spurious noise is typically −50 dB/MHz in broadband, high peak power, S-band tubes. However, this will drop even further through the use of the platinum emitter as greater attention is given to design of the interaction region.

Litton is currently working on an internally funded program to develop a cathode mounted RF circuit. This technology shows considerable promise for improving the noise performance, both in forward-wave and backward-wave tubes.



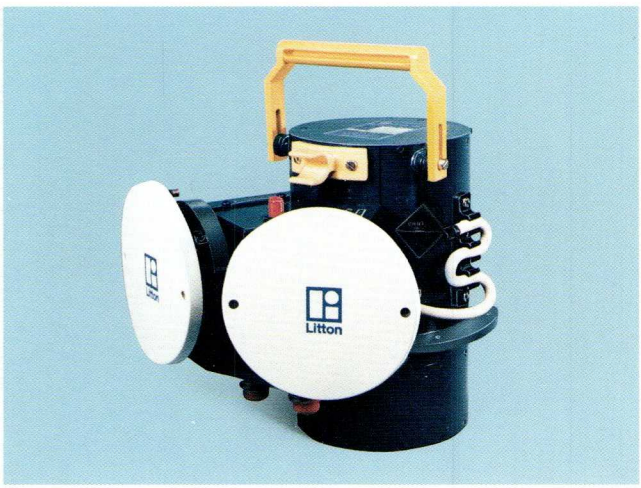
The L-4764A. A lightweight, X-band, .5 MW peak power CFA.

## A range of applications

Litton's successful efforts in enhancing CFA performance have brought the CFA into consideration for a wide range of applications, many for the first time.

Greater pulse stability, phase stability and efficiency have made the CFA an ideal choice for advanced phased array systems such as the AN/SPY-1 radar in the AEGIS system.

Thanks to its relatively low operating voltage, high efficiency and smaller form factor, the CFA is an excellent choice for application in lightweight mobile or transportable radar systems.




The L-4767. A high gain, S-band, forward-wave CFA providing up to 140 kW peak power.

The L-4764A is an example of a new Alnico-9 magnet design that is lightweight and small, yet produces 500 kW peak power at X-band for application in an advanced airborne ASW radar system. This tube is capable of operating at a pulse width of 2.5 to 3.0 microseconds at a duty cycle of .0012.

Litton's forward or backward-wave CFAs can be used in amplifier chains of two or more tubes to maximize output power and gain while minimizing size and weight. The L-4719 is an excellent example of a tube that is fully interchangeable between a driver and final stage. The L-4719 was developed for a United States Navy advanced shipboard 3-D radar.

Litton CFAs are also practical for systems requiring multi-mode operation. Lower level drive power can feed through the final stage with minimum degradation in system efficiency due to the inherently low insertion loss of the CFA.

# A commitment to CFAs.

Since 1980 Litton's facility for the manufacture, assembly and testing of crossed-field amplifiers has increased to more than 50,000 square feet. There is also the flexibility to increase this space on short notice to respond to market needs.

Computer-controlled fabricating equipment allows Litton to maintain the precision of machined parts and minimize reliance on outside vendors. Tight process, material and quality controls ensure high reliability and low life-cycle cost. And the entire CFA area is fully qualified to MIL-Q-9858A standards.

Litton's high standards provide the necessary environment to produce the vital platinum and beryllium oxide cathode emitters. These cathodes require no filament, and therefore, no warm-up time or filament supply is needed. As Litton manufactures the cermet-type cathode commonly used in earlier model CFAs, it has the capability to repair almost any CFA still in use in high power radar systems.

In addition, Litton has the capability to build the high voltage power supplies and modulators required for CFA test stations.

**Responsive to customer needs**

The rapid growth in CFAs is a reflection of Litton's commitment to CFA technology and willingness to accommodate customer needs.

Litton regularly takes the initiative in developing new products and making prototypes available to potential users.

Litton also responds to special customer requests. On its own, Litton will frequently undertake internally funded engineering programs, then build the sample and work closely with the system designer to fit the product to his specific application.

Today, the world is witnessing a renaissance in the use of CFAs. As a result of increases in gain and dynamic range, it is now becoming practical to consider CFAs in many applications traditionally dominated by other microwave devices.

If you need crossed-field amplifiers in L, S, C, and X-bands at any output levels, talk to the company that is writing a new chapter in CFA technology.

Litton. The new power in CFAs.

# Litton CFA products.

## Typical Performance:

| Parameters | L-4717 | L-4718 | L-4719 | L-4756 | L-4762 | L-4764 | L-4765 | L-4767 | L-4716 |
|---|---|---|---|---|---|---|---|---|---|
| Freq. Range (GHz) | 2.9-3.1 | 2.9-3.1 | 2.9-3.1 | 3.09-3.51 | 3.1-3.5 | 9.5-10.0 | 2.9-3.1 | 2.9-3.1 | 2.9-3.1 |
| Peak Power (kW)* | 60 | 666 | **525/ 2200 | 1200 | 125 | 500 | 2600 | 60 | 666 |
| Duty Cycle | .028 | .0148 | **.025/ .0125 | .025 | .016 | .0011 | .0053 | .028 | .015 |
| Gain (dB) | 16 | 11 | 10/7 | 10 | 16 | 12 | 7 | 16 | 11 |
| Efficiency (%) | 60 | 60 | 60 | 50 | 40 | 39 | 60 | 45 | 66 |
| Bandwidth (%) | 6.67 | 6.67 | 6.67 | 12.7 | 12.1 | 5.1 | 6.67 | 6.67 | 6.67 |
| Pulse Width ($\mu$sec.) | 35 | 30 | 28 | 110 | 16 | 2 | 28 | 36 | 30 |
| Insertion Loss (dB) | 0.4 | 2.0 | 1.0 | 2.0 | 2.0 | 1.3 | 1.0 | 2.0 | 1.0 |
| Spurious Noise (dB) | −35 | −35 | −35 | −40 | −40 | −35 | −35 | −40 | −35 |

*Output power is expressed as "Minimum" over the specific band.
**Operates at 525 kW peak power at .025 duty and 2.2 MW peak power at .0125 duty.

## Mechanical:

| Mounting Position | Any | Any | Any | Any | Any | Any | Any | Any | Any |
|---|---|---|---|---|---|---|---|---|---|
| Weight (lbs.) | 55 | 130 | 220 | 220 | 45 | 27 | 150 | 45 | 150 |
| Emitter | $ThO_2$ | Cermet w/$ThO_2$ | Pt | Pt | BeO | Cermet w/$ThO_2$ | Pt | BeO | Pt |
| Circuit | BW | BW | BW | BW | FW | BW | BW | FW | BW |
| Mating Flange | UG-54B/U | UG-54B/U | CPR-284 | CPR-284 | UG-54B/U | UG-137 | UG-54B/U | UG-54B/U | UG-54B/U |

## Operating Conditions:

| | L-4717 | L-4718 | L-4719 | L-4756 | L-4762 | L-4764 | L-4765 | L-4767 | L-4716 |
|---|---|---|---|---|---|---|---|---|---|
| Anode Voltage (kV) | 27 | 55 | 57 | 37 | 13.6 | 34 | 57.5 | 10.5 | 55 |
| Anode Current (A) | 3.75 | 20 | 60 | 61 | 22 | 37 | 60 | 16 | 20 |
| RF Drive (kW) | 2 | 48 | 48/400* | 125 | 7 | 30 | 550 | 1.6 | 48 |
| VSWR | 1.3:1 | 1.3:1 | 1.3:1 | 1.3:1 | 1.7:1 | 1.3:1 | 1.7:1 | 1.3:1 | 1.3:1 |
| Coolant | Liquid | Liquid | Liquid | Liquid | Liquid | Liquid | Liquid | Liquid | Liquid |
| Flow Rate (GPM) | | | | | | | | | |
| Anode | 1.0 | 3.0 | 12.5 | 3.0 | 0.9 | 3.0 | 3.0 | 0.9 | 3.0 |
| Cathode | — | — | Note 1 | 7.0 | Note 1 | — | Note 1 | Note 1 | Note 1 |
| Window | — | 0.4 | Note 1 | Note 1 | — | — | 0.4 | — | 0.4 |

(Note 1 = Combined Flow)
*48 kW drive for 525 kW peak power and 400 kW drive for 2.2 MW peak power levels.

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**Litton**
Electron Devices

Printed in U.S.A. 5M/3/87