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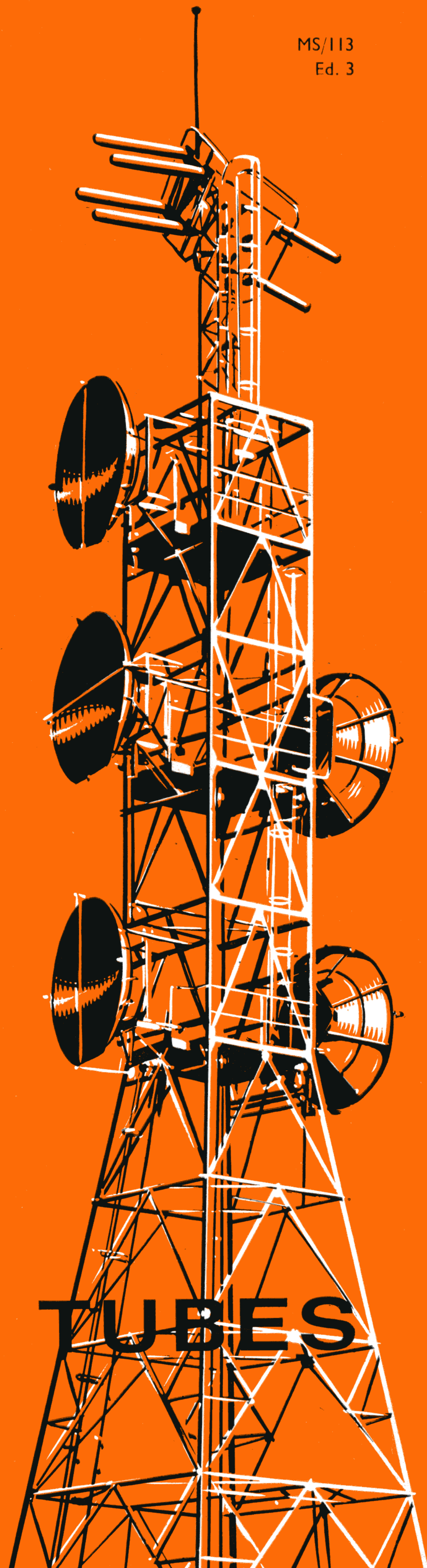


STC MICROWAVE TUBES

Standard Telephones and Cables Limited

Registered Office, Connaught House, 63 Aldwych, London, W.C.2

VALVE SALES DEPARTMENT

FOOTSCRAY · SIDCUP · KENT

Introduction

STC can justly claim to be pioneers in microwave communication. Over a quarter of a century ago (in 1931) STC and their French associates, Le Matériel Téléphonique, Paris, staged the world's first demonstration of super-high-frequency communication by establishing a radio-telephone circuit between Dover and Calais, using a wave length of 17·6 cm.

In 1934, the first commercial S.H.F. system was installed by the same Companies to provide a telegraph link across the English Channel between the civil airports of Lympne and St. Inglevert. This work rapidly established S.H.F. systems as vital to the field of telecommunications and such systems, developed and manufactured by STC, have set the pace in technological advance.

The first Franco-British television exchange; the first B.B.C. outside TV broadcast; the historic Coronation cross-Channel TV link; the first B.B.C. outside TV broadcast from Ireland—these are milestones in STC's programme in the development and application of S.H.F. communications.

Part of the British Post Office television transmission network in Great Britain is the permanent STC S.H.F. system linking Manchester with Kirk O'Shotts and with an extension to Aberdeen. These and other completed and projected S.H.F. installations in the countries listed below are a measure of the leading rôle that STC is playing in the provision of national and international microwave telephone and television links.

AUSTRALIA
AUSTRIA
BAHAMAS
BRAZIL
CANADA
FRANCE
JAPAN
MALAYA
MALTA
MOROCCO
NEW ZEALAND
NORWAY
REPUBLIC OF IRELAND
SOUTH AFRICA
SPAIN
SWEDEN
SWITZERLAND
TANGIER
UNITED KINGDOM

The STC Special Valve Division Laboratories and Factory at Paignton, Devon, England

Introduction *(Continued)*

Concurrently with the growth of the S.H.F. system of communication considerable research and development was taking place in the STC Special Valve Division to produce the special microwave tube types necessary for these new applications. In consequence, STC is able to offer a comprehensive range of velocity modulated oscillators and travelling-wave tubes, any one of which can be relied upon to give the same dependable and efficient service being given by several types in a number of the completed installations just referred to. Furthermore, from the first pioneering efforts in 1931 to the present day, STC engineers have accumulated considerable practical experience in dealing with the special problems associated with microwave communication. A comprehensive applications and information service is at the disposal of the customer to assist him with design and development problems. Where the characteristics of available types do not meet the designer's requirements completely, it is often possible to tailor an existing tube to meet the application as, for example, by slightly changing the frequency coverage of an oscillator.

The following pages are devoted to travelling-wave tubes and oscillators in the present range. Brief descriptions are given of the intended applications and characteristics of the tubes.

General view of a section of the STC Microwave Tube Laboratories at the Paignton Works

Travelling-wave Tubes

Standard Telephones and Cables Limited have been in the forefront of design and production of travelling-wave tubes from the time of their conception; over these many years the Company has built up a wealth of technological ability and proven reliability.

Development has been broadly carried out along two paths;

1. Special types for military uses;
2. Tubes for television or multi-channel telephony link communications.

However, most of the tubes have the following common design features:

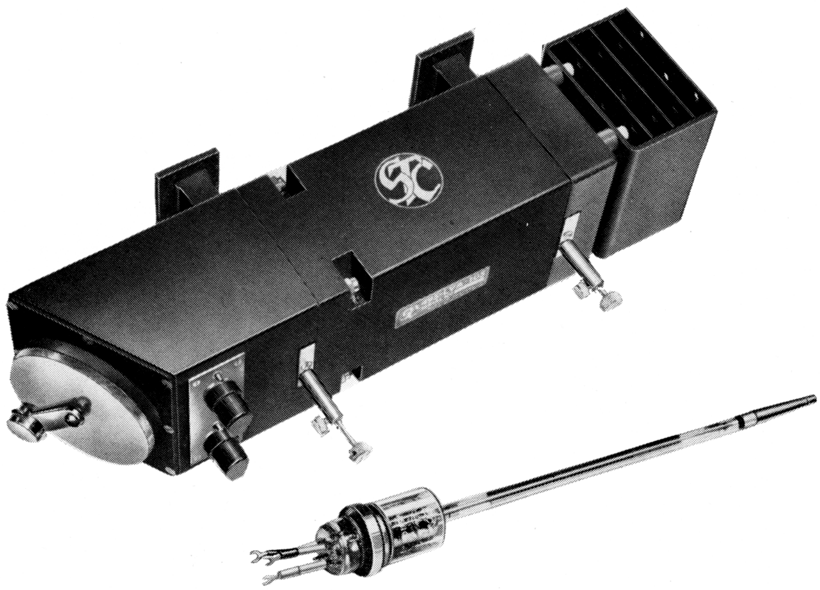
1. Short-circuit stability at high gain levels.
2. Excellent matching characteristics.
3. Simple beam alignment without mechanical adjustment (for rapid tube replacement).
4. Hard glass envelope with fork ring seals for strength.
5. Long life.
6. Simple reliable construction incorporating only the necessary basic features (to reduce tube replacement costs).

Recent design advances are: coaxial line feed, permanent magnet focusing and a trend towards lower voltage working, coupled with higher efficiencies where applicable.

The following list indicates some of the more interesting types which are currently available.

Code	*CV No.*	*Base*	*Circuits Available*	*Circuit Code*	*RF Connection*	*Frequency Range Gc/s*	*Maximum Power Output mW*	*Low Level Gain dB*	*Noise Factor dB*
W5/1G		Special Flying Lead	Periodic Permanent Magnet	495–LVA–105*	Waveguide	5·8–7·2	10 000	38	—
W7/3G	5293	Special Flying Lead	Periodic Permanent Magnet Aluminium Foil Solenoid	495–LVA–104 495–LVA–009	Waveguide	3·6–4·2	10 000	28	27
W7/4G		Special Flying Lead	Periodic Permanent Magnet	495–LVA–101 495–LVA–106	Waveguide Coaxial	3·6–4·2 2·6–3·7	10 000 8 000	42 36	27 —
W9/1E	2499	Special B9A	Aluminium Foil Solenoid or Permanent Magnet	495–LVA–001 495–LVA–102	Coaxial	2·5–4·1	120	36	18
W9/2E	6099	Special B9A	Aluminium Foil Solenoid	495–LVA–005	Coaxial	2·5–4·1	10	40	8·5
W9/3E		Special B9A	Aluminium Foil Solenoid	495–LVA–007	Coaxial	2·5–4·1	0·1	15	16
W10/3E		Special B9A	Copper or Aluminium Foil Solenoid	495–LVA–003 495–LVA–006	Waveguide Coaxial	2·7–3·3 2·8–3·7	3	23	6·8

* A suffix letter denotes waveguide flange and focusing details.



W5/1G and Periodic Permanent Magnet Focusing Circuit 495–LVA–105C

W5/1G

This comparatively small tube has a performance of 38 dB gain and a maximum power output of about 10 watts over the 5·8 to 7·2 Gc/s band. A useful performance can be obtained up to 8·2 Gc/s.

Compact circuits are available with waveguide r.f. connexions and periodic permanent magnet focusing (as illustrated).

A choice of three waveguide flanges can be provided and focusing adjustment for individual tubes can be entirely mechanical or combined with remotely controlled deflector coils. The type of convector cooler fitted is appropriate to the intended plane of mounting the unit.

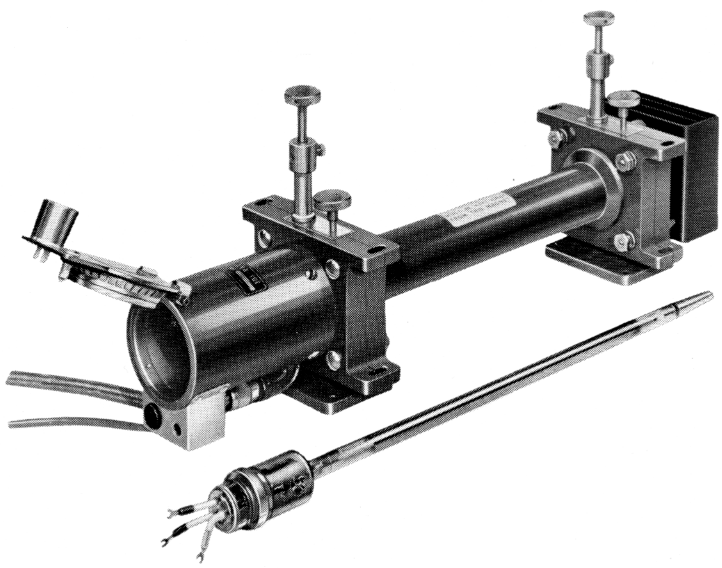
W7/3G (CV5293), W7/4G

Designed specifically as output stages in multi-channel link systems, these two tubes are nominally for the band 3·6–4·2 Gc/s, and have been well proved in service in many parts of the world. The W7/4G is similar to W7/3G in ratings and maximum power output but has a considerably higher gain.

Bandwidths of greater than 1 000 Mc/s are obtainable.

Both tubes are available with light-weight periodic permanent magnet or aluminium foil solenoid focusing systems. With waveguide r.f. connexions a useful performance can be obtained up to 5 Gc/s and with coaxial connexions the performance between 2·6 and 3·7 Gc/s is 36 dB gain at 4 watts output for the W7/4G.

The mounts are fitted with fins which afford adequate cooling by natural convection for collector dissipation up to 80 watts.



W7/4G and Periodic Permanent Magnet Focusing Circuit 495–LVA–101

W9/1E (CV2499) S-band Low-level, High-gain Tube

This tube is primarily intended as a wide-band r.f. amplifier and, since the noise factor is only 18 dB, it can be used after a low noise input stage without introducing additional system noise.

Its great flexibility of design and rugged construction render it suitable for many other applications; it is also a suitable type for use by universities and technical colleges for educational purposes.

This tube may be used to precede type W7/4G in a circuit with coaxial connectors and together they provide an overall gain of over 60 dB.

Special features include:

50 Ω coaxial line feed (type B.N.C. connectors).

Permanent magnet or lightweight aluminium foil solenoid focusing.

Low operating voltage of 400 volts.

Saturated output power of 120 milliwatts.

Gain of 35 dB.

V.S.W.R. less than 2 over the band without tuning.

Conduction cooling.

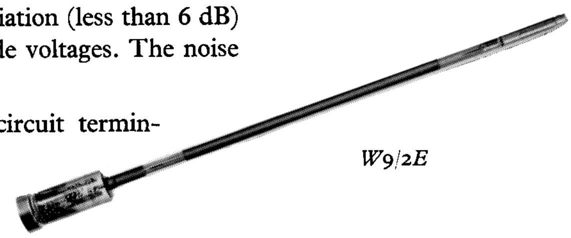
Rugged structure.

W9/1E and Permanent Magnet Circuit

W9/2E
(CV6099) S-band Low-noise Tube

This tube is intended for high gain (42 dB) with little variation (less than 6 dB) over the frequency range 2·5 to 4·1 Gc/s at fixed electrode voltages. The noise factor over this band is less than 10 dB.

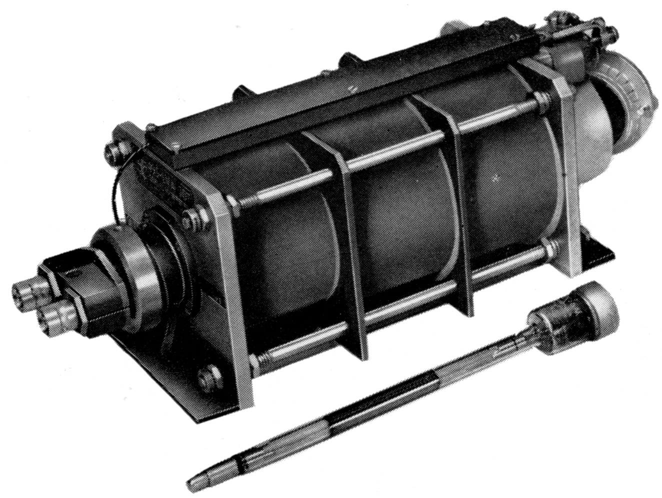
An aluminium foil solenoid is available with the r.f. circuit terminated by rigidly mounted 50 Ω coaxial type C connectors.



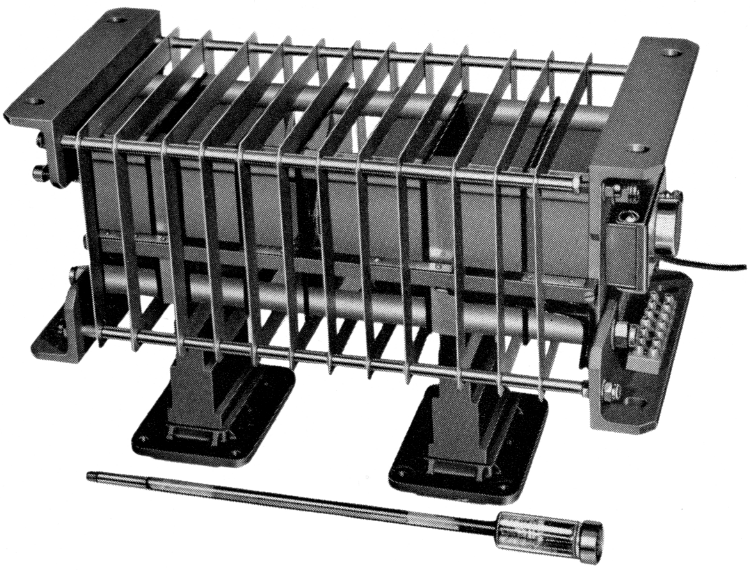
W9/2E

W9/3E
S-band Limiter Tube

This tube has a maximum output of 100 μW and thus attenuates input power exceeding this figure. However, the tube has a low-level gain of typically 15 dB and two of these tubes connected in cascade yield a remarkably constant output for wide variations of input power.



W9/3E and Aluminium Foil Solenoid



W10/3E and mount 495-LVA-003

W10/3E

This new S-band low-noise tube has been designed specifically for use as the r.f. input stage in radar receivers. It operates with a typical noise figure of 6·5 dB at a gain of 23 dB. It is now commercially available and offers a significant advance over any other type in this class.

Two circuits are available for use with W10/3E.

Type 495-LVA-003

This circuit comprises a copper foil focusing solenoid with standard 10 cm waveguide input and output and enables the amplifier to cover the frequency range 2·7 to 3·3 Gc/s. This circuit is fitted with magnetic screening laminations.

Type 495-LVA-006

This circuit comprises an aluminium foil focusing solenoid and coaxial type C connectors and enables the amplifier to cover the frequency range 2·8 to 3·7 Gc/s. A version with magnetic screen (illustrated) is coded 495–LVA–006S.

W10/3E and circuit 495-LVA-006S

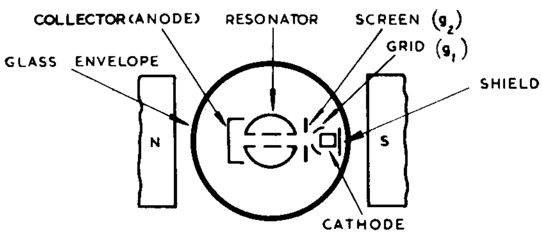
Microwave Power Generators

Velocity Modulated Oscillators

Since 1939, a comprehensive range of single transit coaxial line oscillators (Heil tubes) has been built up covering the frequency range 0·9–6 Gc/s. Types are available having wide mechanical or electronic tuning, wave guide or coaxial mounting, or any combination of these features.

The principle of operation is best explained by reference to the diagram below which shows a cross-section of the tube structure. An electron stream is accelerated from the cathode by the screen and is focused by the grid and magnet into a beam. The beam traverses the two interaction gaps in the resonator and is collected by the anode. The resonator is, effectively, a section of coaxial line with a hollow centre conductor. Interaction occurs between the beam and the field between the centre and outer conductors. The frequency is determined by the cavity to which the structure is coupled and by the potential difference between resonator and cathode. Variation of this potential difference affords a means of frequency modulation.

Application of the screen grid voltage in pulses provides the facility for square wave amplitude modulation. Constant output may be achieved by providing a means of adjusting the screen voltage to keep the cathode current constant.



Cross-section of tube assembly

STC microwave oscillator tubes are designed for long life which is an important requirement in microwave links in which many of these tubes are used.

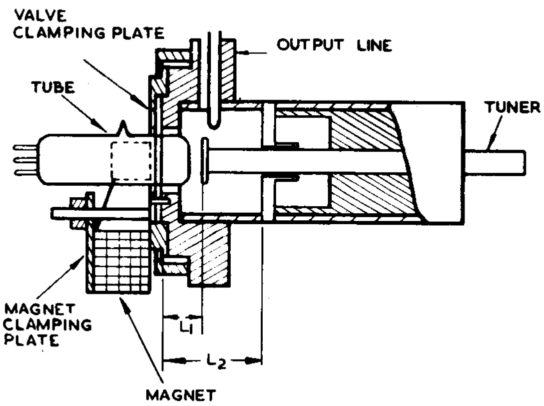
The letter A immediately in front of the oblique stroke in the Commercial Code indicates a tube designed primarily for wide mechanical tuning range, and similarly the letter C indicates a tube designed for electronic tuning.

Commercial Code	*CV Number*	*Suitable Cavity*	*Frequency Range Mc/s*	*Minimum Power Output W*	*Resonator Voltage Range V*	*Cathode Current mA*	*Minimum Electronic Tuning Range Mc/s*
V190C/1M	—	495–LVA–202	500– 925	0·25	180	40	±1
		495–LVA–203	800–1000	2	180–270	80	±2
V218A/1K	—	—	1700–2000	0·5	200–300	50	—
V231C/1K	—	495–LVA–252	3060–3180	0·05	180–240	45	±8
V233A/1K	2190	495–LVA–201	2700–4200	0·3	190–380	50–65	±1
V235A/1K	2221	495–LVA–226	2700–4000	0·5	190–350	50–65	±1
V237C/1K	—	495–LVA–251	3560–3820	0·35	225–285	45	±4
V238A/1K	5292	495–LVA–251	3500–4300	0·55	260–400	50	±1
V239C/1K	5048	495–LVA–251	3780–4040	0·35	225–285	45	±4
V241C/1K	5049	495–LVA–251	4000–4240	0·35	225–285	45	±4
V243A/2FS	5463	495–LVA–251	4100–4600	0·75	235–275	65	—
V245C/1K	—	* 495–LVA–251	4400–4630	0·2	230–265	50	±8·5
V246A/2K	485	495–LVA–251	4580–4860	0·25	200–250	40	±3
V246C/4K	2422	495–LVA–251	4400–4850	0·3	280–360	50	±3
V247C/1K	—	* 495–LVA–251	4570–4750	0·2	230–265	50	±8·5
V249C/1K	—	* 495–LVA–251	4760–5000	0·2	240–290	50	±8

* For waveguide output the cavity is type 439–LTA–32A.

The collector voltage is preferably set 10–20 volts above resonator potential. The resonator is usually connected directly to a grounded cavity and the cathode operated at a negative potential. When frequency modulation is required, the resonator may be insulated from the cavity by a mica washer.

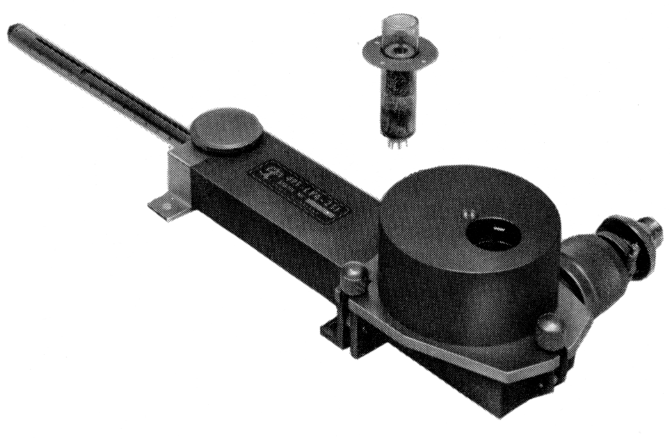
"A" TYPES



V235A/1K (CV2221)

When operated in the simple recommended coaxial cavity, this oscillator provides a typical power output of more than 0·7 watts and tunes mechanically over the frequency range 2·6–4·1 Gc/s. Its freedom from spurious moding, and ease of tuning, have made it a very widely used and popular tube for laboratory bench work and the many other applications where wide tuning range is required. Power requirements are 175–400 volts at 15 watts. Output is via 50 Ω or 70 Ω coaxial line loop-coupled to the cavity.

The illustration shows the cross section of a typical coaxial line cavity and indicates the dimensions L_1 and L_2 which are critical in determining the resonant frequency.



A versatile cavity 495–*LVA*–251 *for Coaxial Line Oscillators*

V238A/1K (CV5292)

This tube is characterized by high power output (typical 1 W), excellent frequency stability in the range 3 560–4 240 Mc/s. For laboratory work it may be used in waveguide cavity 495–LVA–251 which is fitted with coaxial output socket, as illustrated.

The high frequency stability required for Wide Band Systems is achieved by operating the tube, in its tuning circuit, in a temperature controlled oven with carefully regulated power supplies. Under these conditions a long-term frequency stability can be obtained which is better than $\pm$250 kc/s in the frequency range 3 550–4 250 Mc/s.

V238A/1K is extensively used in radio links operating in many parts of the world.

V243A/2FS (CV5463)

This oscillator tube was introduced primarily for use in the STC Miniature Radio Altimeter in which the tube operates, with a minimum power output of 750 mW, in a waveguide cavity designed for mechanical frequency modulation of $\pm$50 Mc/s in the band 4 200 to 4 400 Mc/s. If, however, the V243A/2FS is mounted in the waveguide cavity 495–LVA–251 illustrated above the frequency range can be increased to cover 4 100 to 4 600 Mc/s.

The tube is designed to withstand mechanical shock and vibration and to operate in ambient temperatures up to 100°C.

This tube is now fitted with a heat dissipating shield as a standard attachment.

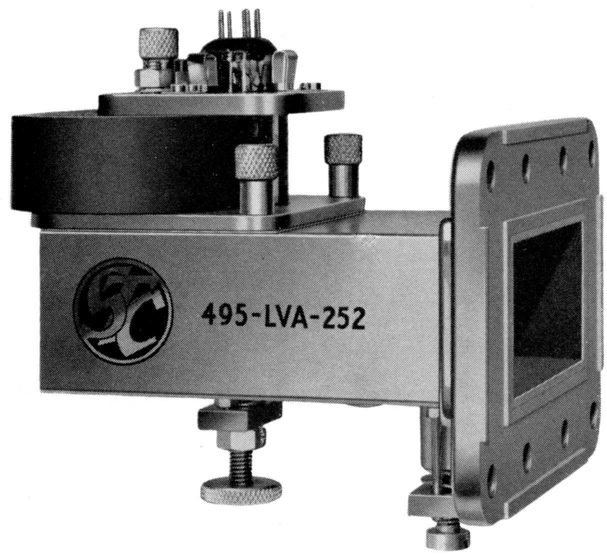
"C" TYPES

V190C/1M

This oscillator tube is unique in having its coaxial line terminated by an open instead of short circuit. Frequency modulation or A.F.C. can therefore be effected by modulating the drift tube potential. The power output over the frequency range 800 to 1 000 Mc/s is over 2 watts and a useful performance at reduced power output is obtainable at lower frequencies down to 470 Mc/s; hence this tube can cover U.H.F. bands IV (470 to 585 Mc/s) and V (610 to 960 Mc/s).
When used in cavity 495–LVA–203, the tube resonator voltage and d.c. drift tube potential is set for the centre frequency required but in the more compact cavity 495–LVA–202 for the lower frequencies the tube is operated at constant resonator potential and electronic tuning achieved by variation of the drift tube voltage alone.

V231C/1K

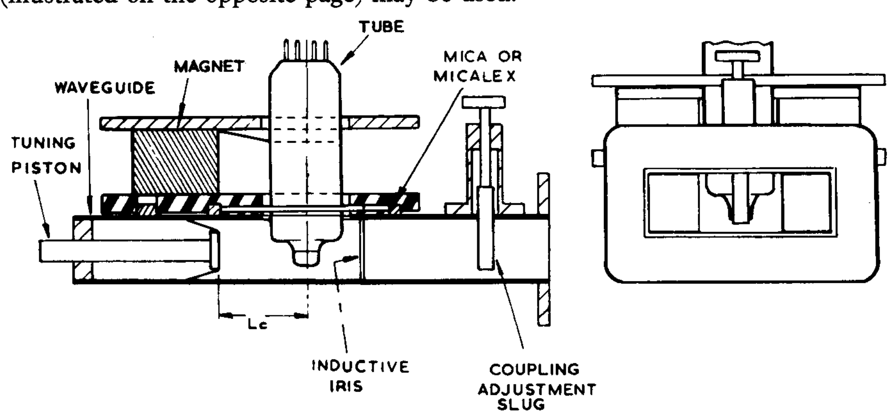
This tube was developed for local oscillator use in S–band radar and provides a minimum output of 40 mW in the frequency range 3 040 to 3 120 Mc/s and may be electronically tuned over a range of ±10 Mc/s. The inexpensive cavity with which it is used is compact in design and both mechanical tuning and power output control are achieved by simple screw adjustments.



A Simple Waveguide Cavity 495–*LVA*–252 *for V*231*C/*1*K*

V245C/1K, V247C/1K V249C/1K

This family comprising three tubes covers an overall frequency range of 4 400 to 5 000 Mc/s. Their comparatively wide electronic tuning range makes them eminently suitable for local oscillator operation or in applications such as frequency modulation at radio frequency, as in multichannel links. This latter application has been well proven in the field in STC links. These tubes are intended for operation in waveguide cavities feeding directly into systems via matching slugs, and will deliver approximately ¼ watt. A cross section of a typical circuit is shown below. If a coaxial output socket is preferred cavity 495–LVA–251 (illustrated on the opposite page) may be used.



H-Wave Oscillators

The most recent addition to the range of low-power oscillators designed specifically to meet communications requirements is a device called the H-wave oscillator.

In principle, this is similar to the familiar Heil tube, but instead of beam bunching occurring in a hollow section of short-circuited coaxial line, it occurs across a short-circuited section of waveguide. In this configuration the interaction gaps are put in series, instead of parallel, which gives higher efficiency. These tubes feature very high frequency stability which means that, in many cases, a complex automatic frequency control system is not necessary. The beam drift tube is d.c. isolated, electronic tuning potentials being applied to this electrode. Electronic tuning bandwidths on the current types are typically ± 10 Mc/s, with the exception of the V265A/1M, and linearity is equivalent to that obtained from reflex klystrons. An additional feature is high efficiency at comparatively low voltage operation (500 volts) to give outputs of the order of 1 watt.

These tubes require no forced-air cooling and are packaged with their focusing magnet. Mechanical tuning is by means of a "dumb-bell" micrometer short-circuit, attached by a quick-release clamp mechanism. Output is into standard WG14 waveguide through an adjustable stub matching section.

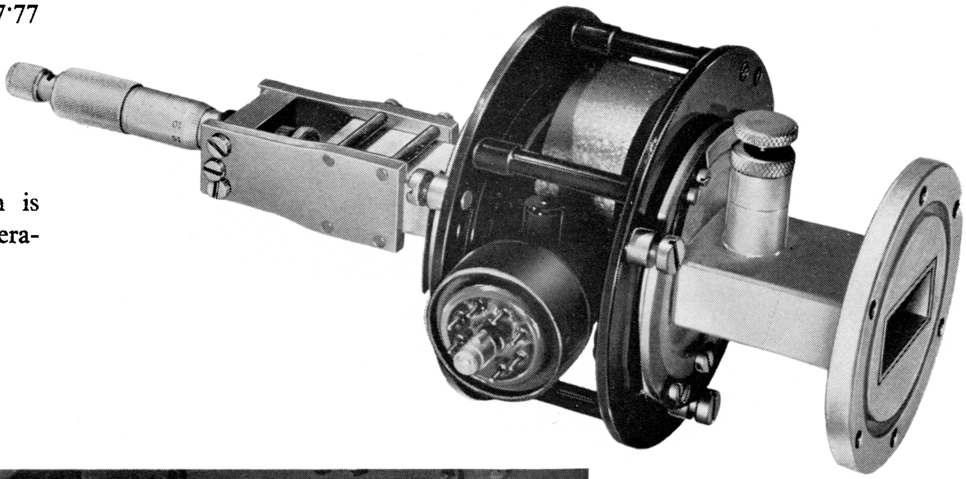
Commercial Code	*Frequency Range Mc/s*	*Minimum Power Output (W)*	*Resonator Voltage*	*Cathode Current mA*	*Minimum Electronic Tuning Range Mc/s*
V261C/1M	5850–6350	0·8	530	60	±8·5
V265A/1M	5850–7100	0·2	230–420	50	—
V266C/1M	6350–6850	0·8	530	60	±8·5
V271C/3M	6850–7350	0·8	530	60	±8·5
V275C/3M	7250–7770	0·8	530	60	±8·5

V265A/1M

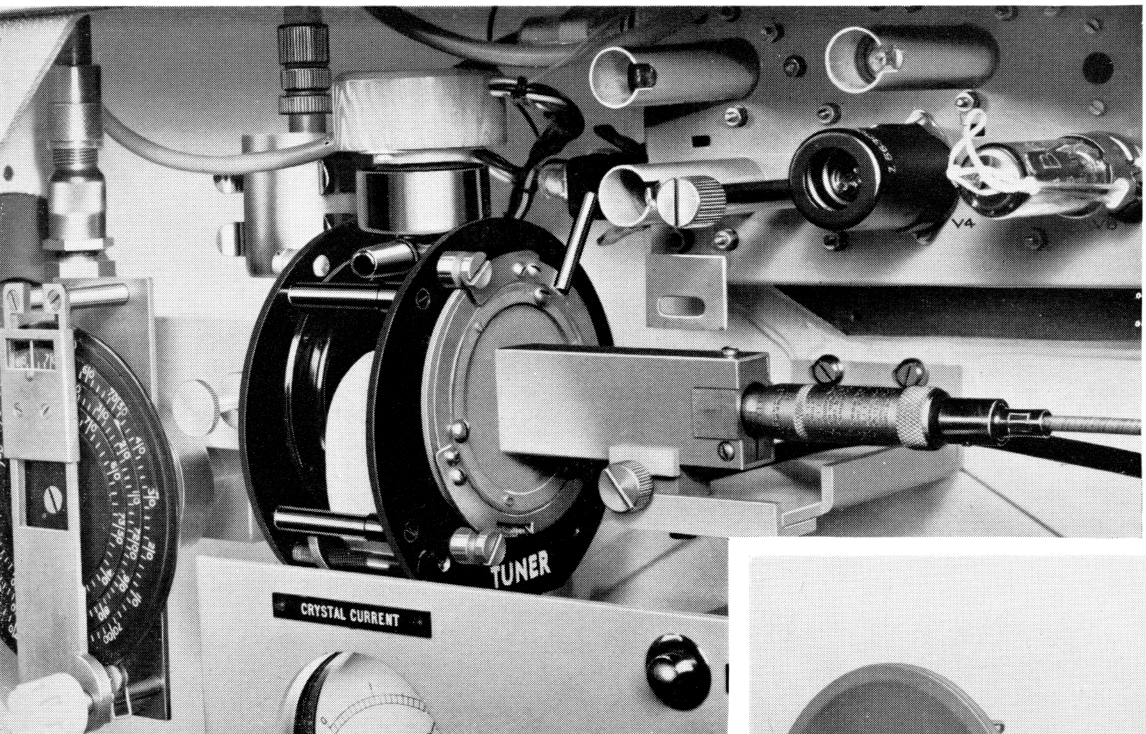
This tube has a useful performance over a wide mechanical tuning range. The power output is typically 400 mW which makes it an ideal device for use as a local oscillator or in microwave test equipment. The tuning range may be extended to 5·7 to 7·5 Gc/s if a lower power output is acceptable.

V261C/1M, V266C/1M, V271C/3M, V275C/3M

These four tubes together cover the frequency band 5·85 to 7·77 Gc/s and are intended for operation at fixed resonator voltage. Frequency modulation is achieved by varying the drift tube voltage the mean of which is varied with frequency of operation.



Complete oscillator assembly for V271C/3M showing tuning and output coupling circuits



The illustration above shows an H-wave oscillator mounted in a STC portable microwave link transmitter. It is both the oscillator and modulated output valve

The illustration on the right shows a complete portable link equipment with both receiving and transmitting units

Backward-wave Oscillators

The backward-wave oscillator, characterized by its ability to be tuned over bandwidths of nearly an octave purely by electronic means, is rapidly proving itself to be an extremely versatile tool in many microwave applications, from laboratory test gear to radar countermeasures.

Y257/1E, Y257/2E

(Illustrated)

These packaged "C" band backward-wave oscillators are electronically tunable over the range 4–7·5 Gc/s and provide a power output (via 50 Ω type "C" connector) of between 20 and 120 milliwatts. The beam focusing is accomplished either by a light-weight aluminium foil solenoid (type Y257/1E) or, alternatively, a straight field permanent magnet (type Y257/2E). Tube power requirements are 250–1 300 volts at a current of 10–13 milliamps.

Y322/1E

This K–band backward-wave oscillator can be electronically tuned over the range 18 to 26·5 Gc/s with a typical power output of 20 to 200 mW over the frequency range. Beam focusing is achieved by an integral aluminium foil solenoid. Tube power requirements are 650 to 3 000 volts at a current of 10–12 milliamps. The tube is fitted with a d.c. isolator for operation with cathode as well as output waveguide at earth potential. Two grids are provided for amplitude modulation.

Y333/1E

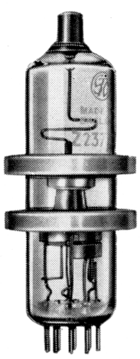
The Y333/1E is a packaged "Q" band backward-wave oscillator capable of being electronically tuned over the frequency range 26·5–40 Gc/s with a power output of 10–50 milliwatts. Output is through a standard WG22 waveguide with a d.c. isolator and beam focusing is accomplished by an aluminium foil solenoid. Power requirements are 700–2 700 volts at 10–12 milliamps.
Two grids are provided for amplitude modulation.

Klystrons

The mechanical tuning range of klystrons is dependent upon the cavities in which they are used and since the present range of STC klystrons are not constructed with integral cavities the performance figures quoted are related to specific cavities in which the tubes are already being used. Therefore the figures do not necessarily indicate the full extent of frequency range over which the tubes could be made to work.

Principal data of STC klystrons is tabulated below:

Code	*Description*	*Frequency Range kMc/s*		*Resonator Voltage V*	*Reflector Collector Voltage*	*Magnetic Field Oersteds*	*Cathode Current*	*Minimum Electronic Tuning Range Mc/s*	*Min Power Output*
		Min	*Max*						
Z211/1G	3 Res Pulse Amplifier	0·96	1·21	5 000	15 000	600	2·5 A pk	—	7 000 W pk
Z220/1G	Refl. Osc.	1·7	2·3	350	−250	—	50 mA	±8	250 mW
Z237/1K	Refl. Osc.	3·5	3·54	350	−150	—	55 mA	±21	125 mW
Z239/1G	Refl. Osc.	3·6	4·2	1 100	−700	—	70 mA	±22·5	1 200 mW



Z237/1K

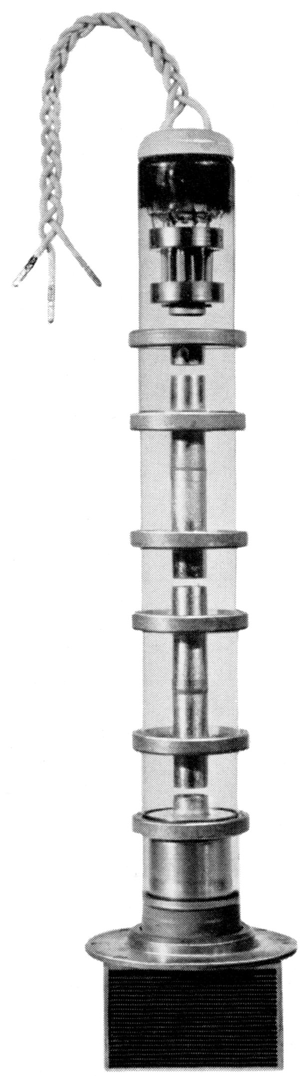
This tube was developed for use as a frequency modulated oscillator in multi-channel radio telephone systems where a high degree of linearity is required. The slope change for a deviation of ±5 Mc/s is between 1 and 2 per cent.

Z211/1G (CV5314)

This klystron is intended for operation as a power amplifier used under conditions of pulse modulation and finds application in the ground equipment of the TACAN aerial navigation beacon.

It is used with three cavity resonators, a continuous r.f. wave being fed into the first at a power level of 3 watts. The output is taken from the third cavity at a peak power of typically 8 kW. The modulator grid adjacent to the electron gun is normally biased to −150 V (beyond cut-off) and a positive pulse of 5 kV applied.

Under these conditions the permitted duty cycle is approximately 3 per cent.

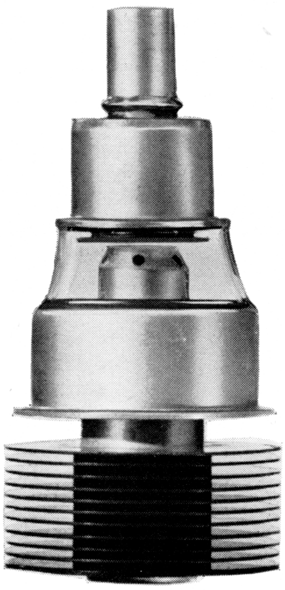


Z211/1G

UHF Triodes

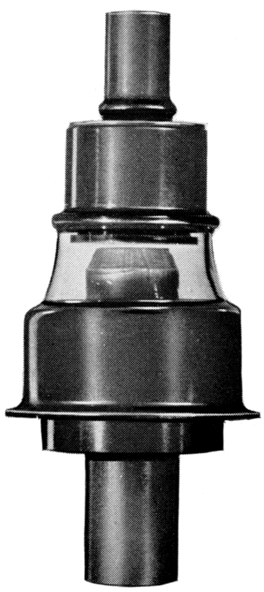
These valves are not confined to microwave applications since their operation is not dependent upon electron velocity modulation. Nevertheless, used in the grounded grid mode and with suitable resonant cavities forming grid and anode circuits they do offer an alternative solution to some L–band microwave amplifier and oscillator design problems.

The two valves illustrated on this page are basically the same type with and without cooling fins on the anode.



2C39A-CV2516-(3H/151J)

The power output of this valve is typically 27 watts at 0·5 Gc/s falling to 12 watts at 2·4 Gc/s as the circuit losses increase with frequency. The maximum anode dissipation is 100 watts if forced air cooling is provided at the rate of 12·5 cu ft/min.

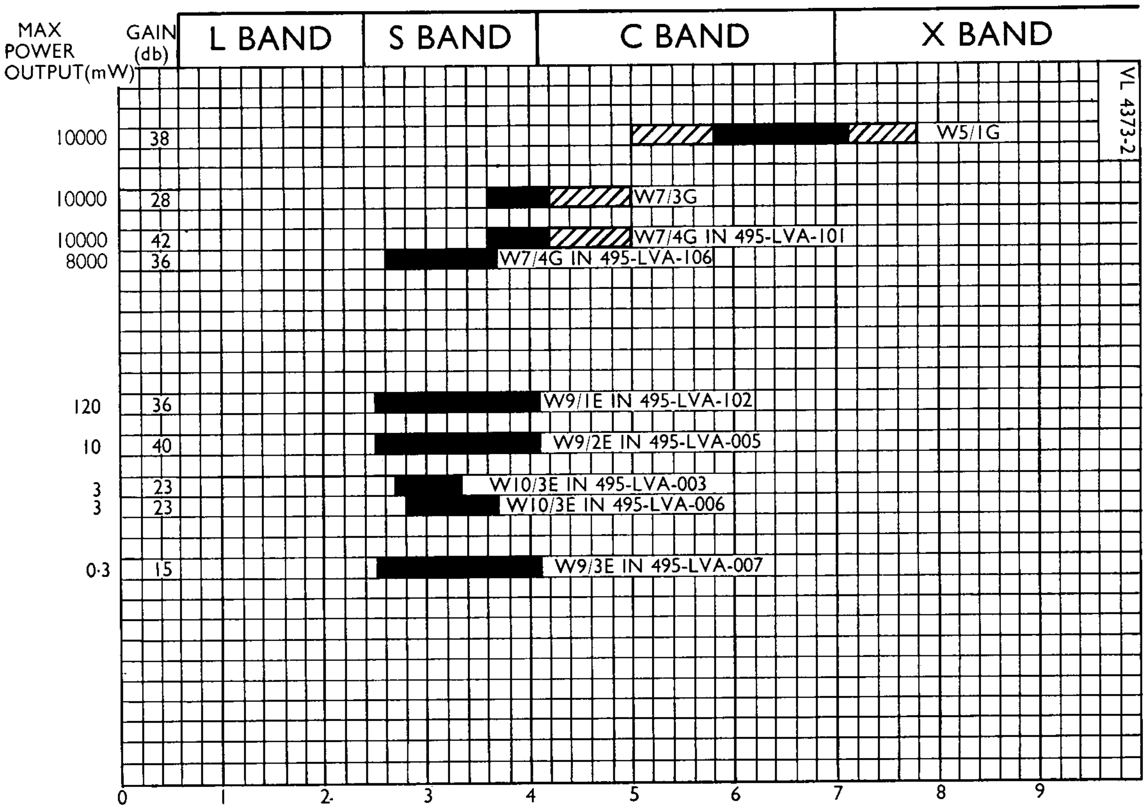


3B/106J

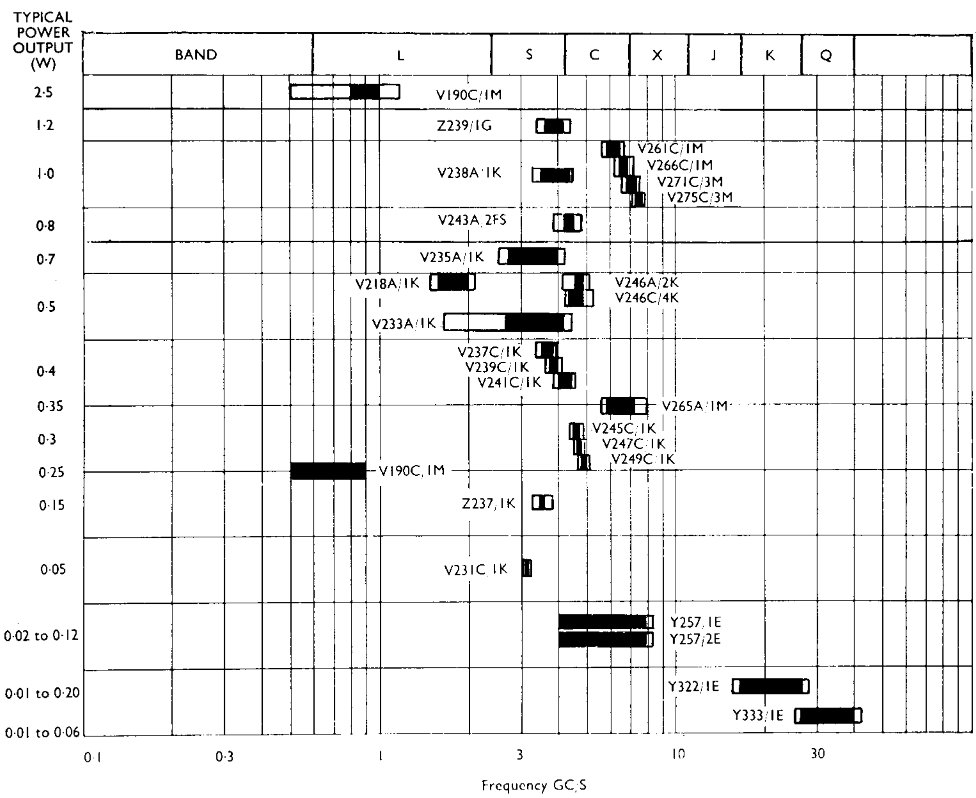
Where pulse operation is required it frequently occurs that the mean anode dissipation does not exceed 10 watts and an anode structure which can be cooled by radiation and contact with the metal cavity is more convenient. Type 3B/106J is designed for this purpose and at 1 Gc/s is capable of delivering up to 2·4 kW peak power output as a pulsed oscillator with a 0·2 per cent duty cycle.

NOMINAL FREQUENCY RANGE/POWER OUTPUT OF AMPLIFIER TUBES

LVA CODES REFER TO FOCUSING & R.F. CIRCUIT TYPES.

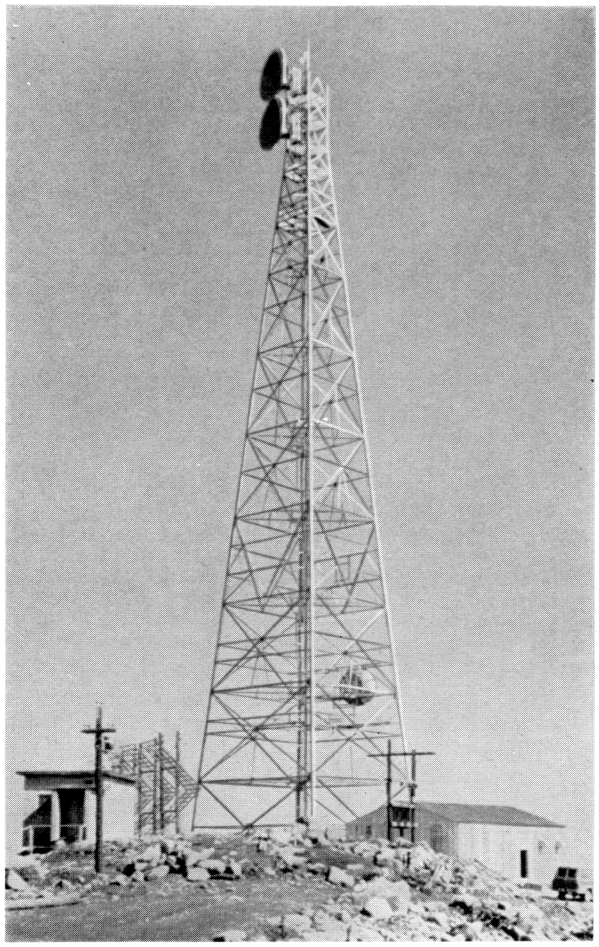


NOMINAL FREQUENCY RANGE/POWER OUTPUT OF OSCILLATORS

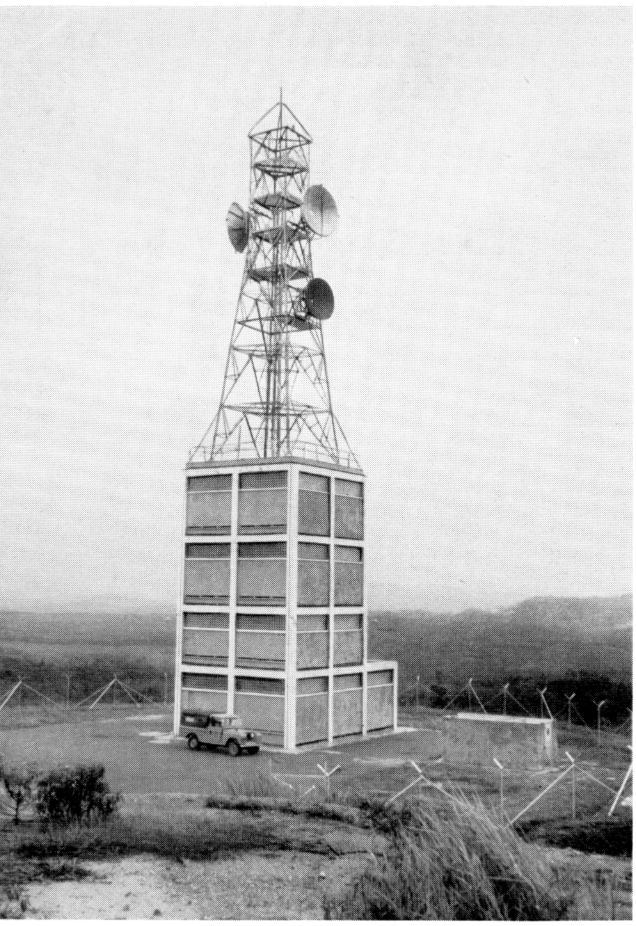


A few of the systems using STC Microwave Tubes

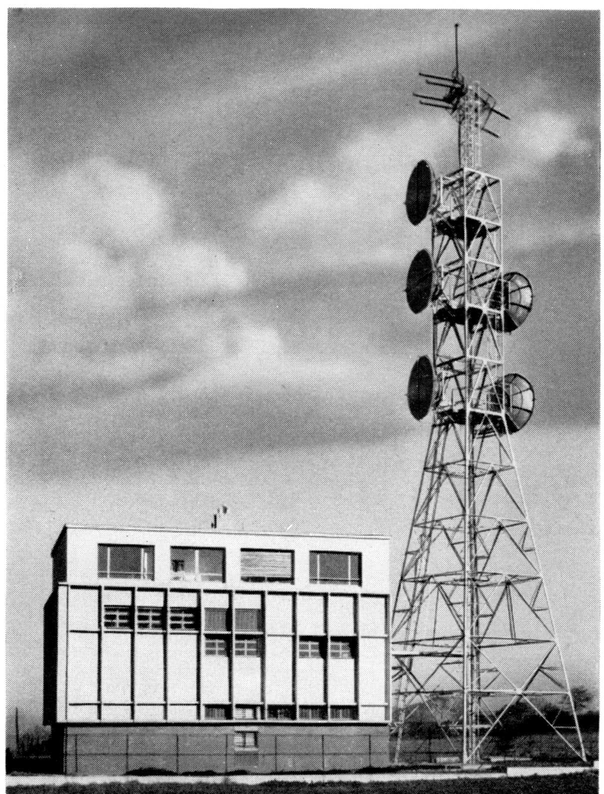
Back-to-back terminal equipment at Koi, Japan, part of a television and telephone microwave link



Tower and antennae at Red Rocks, Newfoundland, the over-water link across the Cabot Straits



Aerial tower and equipment building at Kluang, Malaya. The upper antennae are for the 4 Gc/s system and the lower antennae for the 7 Gc/s system to G. Pulai. The link runs from Singapore to Kuala Lumpur



Fiennes repeater station, France, part of the Anglo-French telephone and television link

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