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Worldwide Use of Siemens Traveling-Wave Tubes in Satellite Ground Stations

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The beginning of commercial usage of the Early Bird satellite on June 28, 1965 marked a new era in worldwide communications. The success of the Early Bird experiment put an end to the controversy concerning the feasibility of communicating via synchronous satellites and demonstrates the great potential of satellite repeaters for global communications systems.

Satellite communications system

A satellite communications system consists of a number of earth stations and at least one satellite as an active repeater station. An important item in every earth station is the transmitter, which must supply the power to overcome the considerable path loss between the earth station and the orbiting satellite (200 dB) with the low distortion and low noise essential in satellite communication, and at the same time meet the stringent economic and reliability requirements of commercial communications systems.

This means that the transmitter tube must satisfy special requirements. The choice of tubes for the currently used transmitting frequencies in the 5.925 to 6.425 GHz band is restricted to multi-cavity klystrons and traveling--wave tubes. For the multi-carrier operation needed in modern multi-access satellite repeater systems, broadband traveling-wave tubes offer a distinct advantage.

Siemens recognized the importance of *high-power traveling--wave tubes* in satellite repeater systems at an early date and initiated appropriate devlopment work [1 to 6], and today occupies a leading position in this sector, and most European as well as many non-European earth stations for the Intelsat III system are equipped with Siemens traveling-wave tubes.

Requirements for transmitter tubes for earth stations

Siemens high-power traveling-wave tubes for earth stations are for the most part designed to meet Intelsat III requirements the first global satellite repeater system of the Intelsat organization. Two synchronous satellites will be placed in an equatorial orbit over the Atlantic and another two over the Pacific and the Indian Oceans respectively. By 1970 some 30 earth stations will be in service in the Atlantic area and some 15 in other areas. Each satellite is provided with two transponders with a bandwidth of 225 MHz each which, operating in conjunction with powerful transmitters at the earth stations, allow the simultaneous transmission of 1200 telephone or four television channels.

High-capacity ground stations will be assigned up to three telephone carriers with 120 voice channels each and one television carrier. Earth stations must be able to radiate an rms power of 82 dBW for each 120-channel carrier. Given the conventional antenna gain of 61 dB and feeder losses of about 3 dB, this means a power requirement of about 250 W per 120-channel carrier at the output of the final amplifier stage. The corresponding maximum power requirement for the television carrier is 1.4 kW.

For an earth station with several carriers, the output stage can be circuited in either of two ways. Either a separate output amplifier may be used for each carrier and the amplified carriers interconnected with switching networks before they reach the antenna, or as many carriers as possible may be combined before they reach the output amplifier and then collectively amplified to the required transmitting level. Fig. 2 provides a schematic representation of the two alternatives for a station with three telephone carriers and one television carrier, where only the telephone carriers are collectively amplified for multi-carrier operation.

The decision as to which of the two options is technically and economically more favorable depends greatly on the linearity of the multi-carrier tubes. The main drawbacks of single-carrier tubes are considerable losses

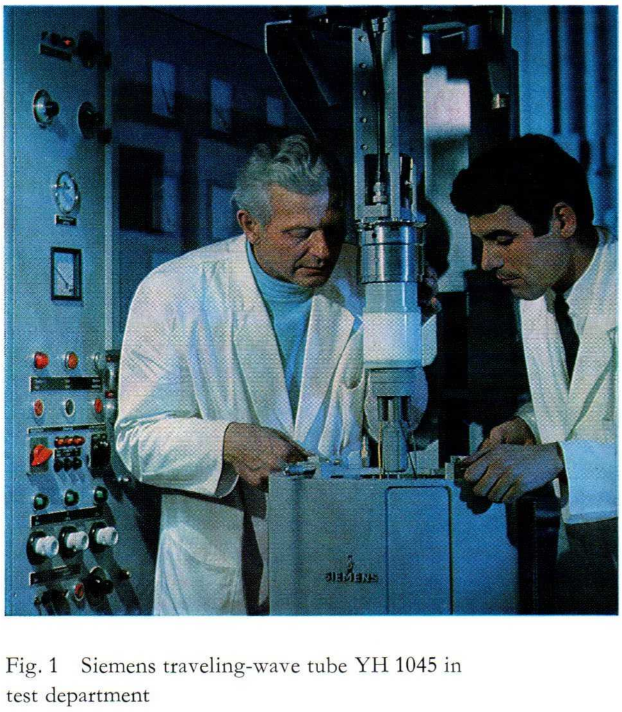

Fig. 1 Siemens traveling-wave tube YH 1045 in test department