HIGH POWER KLYSTRONS FOR HIGH ENERGY PHYSICS RESEARCH APPLICATIONS

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Klystrons have, due to the adaptability of their basic design concept to a large spread of requirements regarding operating frequency, output power level and modes of operation become the predominant source of microwave power in accelerator and fusion reactor applications.

In close cooperation with the various research centres a wide range of high power klystrons have been developed in the Philips-Valvo Tubes and Semiconductor Plant at Hamburg. As the world wide activity center for high power high frequency tubes within the Philips concern, there is a highly experienced team of engineering specialists working, having available a broad range of technological and electrical equipment of highest technical standard and potential for developing and producing microwave power tubes for all kinds of applications and highest power classes (see figure 1).
This contribution surveys the group of high power klystrons, which have been especially developed for applications in the field of High-Energy-Physics research, accelerators and fusion machines and which are tabulated in figure 2.

Following the chronological line the 500 MHz klystron group has been established first starting with the 600 kW type YK 1300 in 1978 and with improved 800 kW type YK 1301. These klystrons are in operation for more than 5 years in the RF-power generators of the ring accelerators at DESY-Hamburg and Cornell University US. The operational experience and knowledge have become the technical basis for further type development and production of klystrons in a broad range of frequencies and RF-power. A follow-up activity of the 500 MHz types has lead to a new most modern design type family of 508 MHz klystrons for 800 kW (YK 1302) and 1100 kW (YK 1303) provided for new accelerator machines. The 1100 kW version YK 1303 in its design technique is based on the experiences and performance properties of the 1100 kW klystron YK 1350 which has been running in test operation since one year and now after prototype approval is in production for the LEP storage ring at CERN.

These 350, 500 and 508 MHz klystrons have been designed for all kinds of water, vapour condensation and vapour cooling techniques with correspondingly horizontal or vertical operating positions with collector up or down, and with air or oil high-voltage isolation.

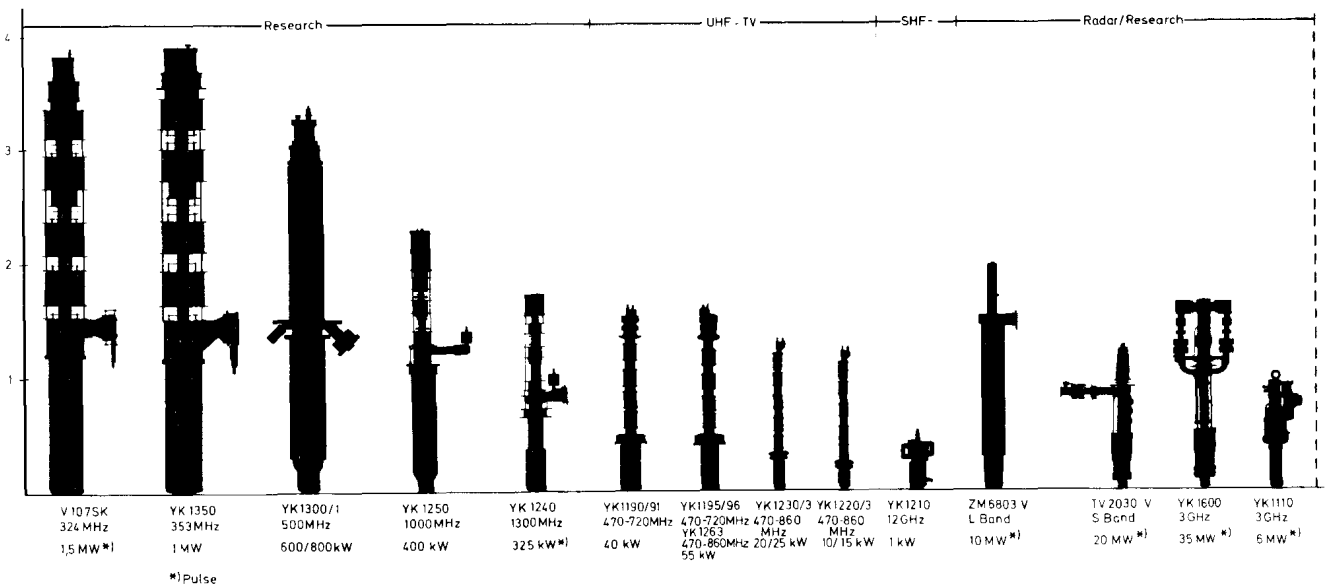


Fig. 1: The Valvo Klystron Skyline

For a planned Heavy-Ion linear accelerator a prototype klystron V107SK has been developed and tested for long pulse operation at 325 MHz and at a power level of 1500 kW. A corresponding development study has resulted in the design lay out and in a gridded gun version for long and short pulse conditions of the 3500 kW version V116SK.

A 400 kW klystron YK 1250 at 1000 MHz followed which is provided for RF-power generators operating at the second harmonic frequency of the PETRA storage ring of DESY for improving the bunching structure of the accelerated electron beam and increasing total beam energy. This is in operation since 4 years.

Another klystron type in this frequency region is a 400 kW cw longpulse type YK 1240 at 1300 MHz, which is in operation in the Plasma Physics Research Center of Garching near Munich.

The lower frequency region studies and development have been started two years ago, aiming at RF-power klystrons at about 200 MHz for Heavy-Ion linear accelerators and injection linacs for electron accelerators. The study has led to two proposed power classes of a 4000 kW and an 8000 kW longpulse version (V149SK) resulting in long size klystrons up to 6 m length due to the low frequency and high power. Based on the study results, a 224 MHz klystron version YK 1320 has been developed for RF-power generators at the lower frequency research field. The first production tube is scheduled for starting research operation at the beginning of 1985.

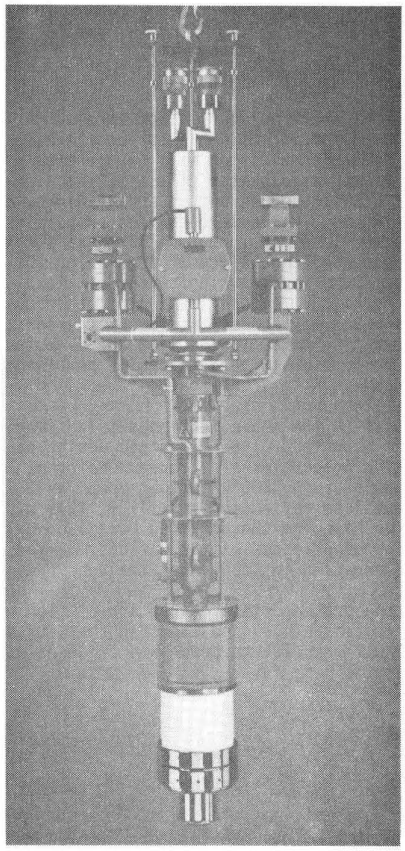
A special short pulse klystron version YK 1600 has been developed for injection linear accelerators at 3 GHz. The production klystron will be operated in the injection linear accelerator of the LEP-accelerator project at CERN. A double output and RF-window design is presenting most reliable operation properties at the high power level of more than 35 MW as specified by CERN having the capability of increasing the power range above 40 MW and ensuring better overload capability under higher load reflection or other operating conditions which may occur outside of the specified maximum operating data. If required the RF-output power can be combined with a waveguide combining-unit and fed into a single transmission line.

Parallel to the above mentioned pulse version a development study has given the basic design parameters and operating properties of a corresponding cw klystron version V139SK having 500 kW output power at 3,7 GHz with maximum load reflection stability. This klystron type will be based on the combined technological and construction experiences of the various cw- and pulse klystrons operating in the higher frequency range.

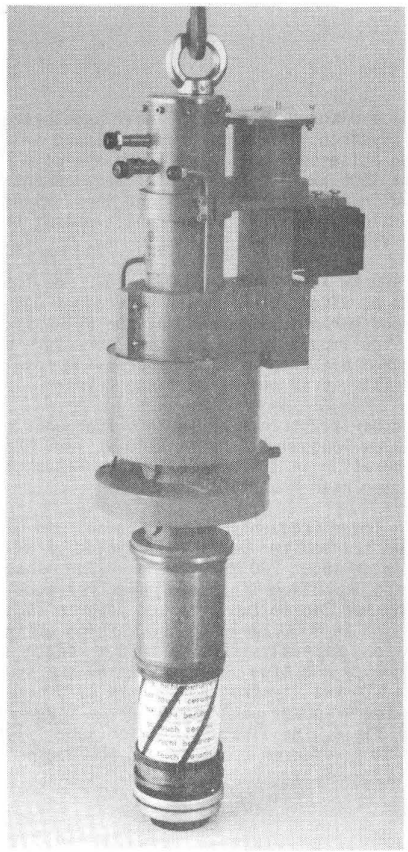
From the present state of the art of high power klystrons it can be seen and expected that further improvements with respect to power and frequencies can be achieved in the near future.

TYPE	FREQUENCY MHz	RF-POWER kW	OPERATION	EFFICIENCY %	BEAM-VOLT. kV	STATUS	INSTITUTES
V149SK	202	> 4 000	LONG-PULSE	>65	140	STUDY	KFA-JÜLICH
YK 1320	224	3 000	LONG-PULSE	55	110	PRODUCTION	EISCAT/TROMSÖ
V107SK	325	1 500	LONG-PULSE	>65	100	PROTOTYPE	KfK-KARLSRUHE
V116SK	325	3 500	LONG-PULSE	>65	140	STUDY	KfK-KARLSRUHE
V103SK	354	1 000	CW	68	85	PROTOTYPE	CERN-GENF (LEP)
YK 1350	354	1 100	CW	68	85	PRODUCTION	CERN-GENF (LEP)
YK 1300	500	600	CW	60	60	PRODUCTION	DESY-HAMBURG/ CORNELL-US
YK 1301	500	800	CW	65	75	PRODUCTION	DESY-HAMBURG
YK 1302	508	800	CW	65	75	PRODUCTION	–
YK 1303	508	1 100	CW	>65	85	DEVELOPMENT	–
YK 1305	500	350	CW	60	48	PRODUCTION	DARESBURY GB
YK 1250	1 000	400	CW	60	60	PRODUCTION	DESY-HAMBURG
YK 1240	1 300	400	LONG-PULSE	55	60	PRODUCTION	IPP-GARCHING
YK 1110	2 998	6 000	PULSE	30	210	PRODUCTION	DESY-HAMBURG
YK 1600	2 998	36 000	PULSE	45	280	PRODUCTION	CERN-GENF (LEP)
V139SK	3 700	500	CW	46	65	DEVELOPMENT	–

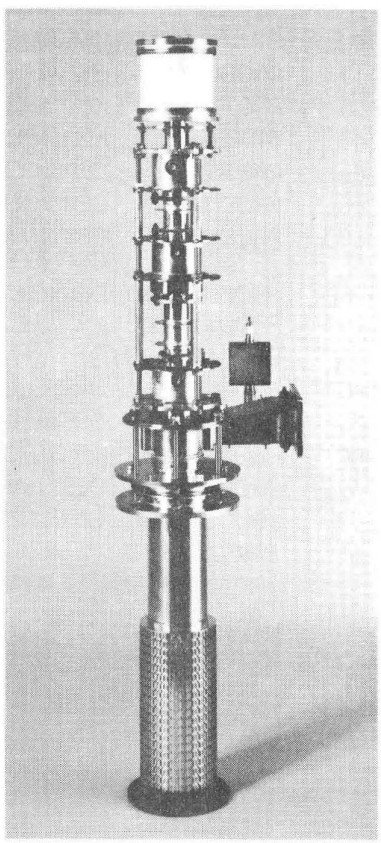
Fig. 2: Klystrons for high-energy-physics application



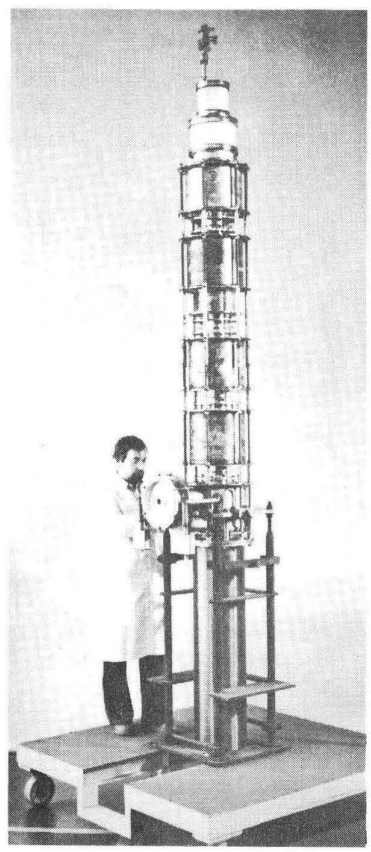
35 MW Pulse-Klystron YK 1600



6 MW Pulse-Klystron YK 1110



400 kW Klystron YK 1240



1,5 MW Klystron V107SK