# German Magnetron Tubes

Very few is known today about the developments of multi-cavity magnetrons in Germany during the war. Available sources just refer to LMS10, a copy of the British CV64 made by Telefunken after the capture of an H2S radar set near Rotterdam. Almost totally obscure are the subsequent steps which led German industries to develop their own power magnetrons, considerably different from those used by Allies. Indeed they came too late for any significant operational uses and anyway their productions were very small, limited to experimental or pre-production samples, to the point that their very existence was doubtful until today.

The use of magnetron tubes for radio-localization transmitters started quite early in Germany. Since 1934 GEMA was experimenting 50 cm systems based upon split-anode magnetron in the transmitter section. Virtually any kind of magnetron was investigated thereafter both in universities and in industries, including water-cooled split-anode types, similar to the 5J29 manufactured by General Electric during the war and used to jam German radars. Due to the poor stability of magnetron generators and even to a more reliable system operation at somewhat lower frequencies, VHF and UHF transmitting triodes were eventually preferred. From 1936 onwards, Germany concentrated all its efforts to prepare the war upon sets operating approximately from 100 to 600 MHz, at the same time abandoning any further research at higher frequencies, as British did. Interdigital magnetrons were used during the war just for CW low-power applications, instead of reflex klystrons.

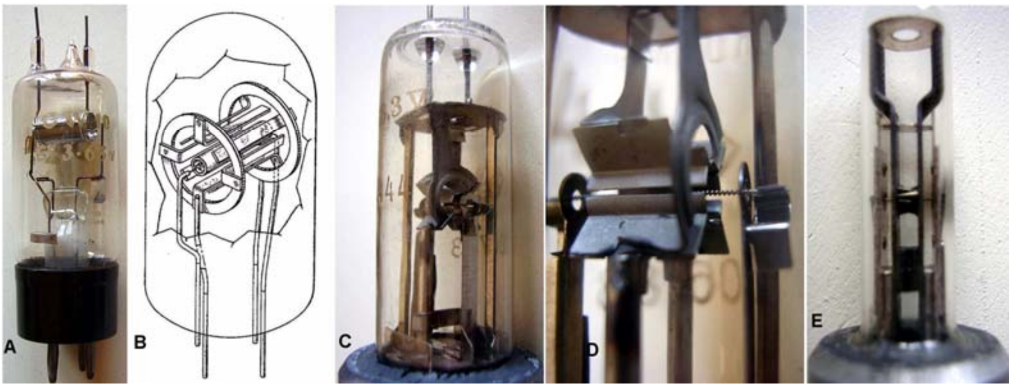


**Fig. 1 - Multi-segment or interdigital magnetrons can be seen as evolutions of the split-anode type. Segment pairs are connected to the external line resonator. A) CW10 was a typical split-anode magnetron available in the mid thirties, widely used in radio-localization experiments. B) Draft of a typical eight-segment interdigital magnetron. Segments are alternately welded to the two side rings and from there to the resonating lines. C) RD4Ma was a four segment CW magnetron designed to operate from 1.1 to 1.6 GHz. D) Close-up view of the four segments surrounding the filamentary cathode. E) RD2Mh could deliver 300 mW CW from 4.3 to 5.5 GHz. It was capacitively coupled to the external resonator. A similar device, the RD2Md, was used as local oscillator in the receiver of the Berlin microwave set. Click on image to enlarge.**

## The multi-cavity power magnetron

Since the early successful experiments in February 1940, British did their best to keep the secret on multi-cavity magnetron. When the early H2S aircraft sets were ready, no authority to fly magnetron-fitted radars over enemy lands was given, fearing that the secret could fall in wrong hands. Around the end of 1941 a variant of H2S, based upon the power klystron CV150, was approved for political, rather than for technical reasons: the capture of a radar set using klystron transmitter would have deceived the enemy, giving information on the state of art in England at the beginning of 1940. The contract for supplying 50 modified H2S went to EMI Hayes, its design being in charge of a group leaded by the television pioneer A.D. Blumlein. Unfortunately, while the entire EMI team was running comparative tests between their prototype and a magnetron equipped

H2S, the V9977 Halifax aircraft where the second system was installed crashed, killing the entire EMI design team. On 15 July 1942 the contract was canceled and thereafter the magnetron version of H2S was authorized to fly over Continental Europe.

Germans learned of the British magnetron few months later, in February 1943, when a Stirling bomber equipped with the 10-cm H2S radar S/N 6 was shot down near Rotterdam. They soon decided to copy the entire system, including the CV64 strapped magnetron. Time was spent to adapt the British design to their different technologies, a necessary step due to shortage of strategic materials, as the cobalt used by Allies in their permanent magnets. As result, some details were changed in the Rotterdam copies and the few sets built were actually completed with permanent magnets from other crashed or captured planes. By May 1943 Telefunken had delivered at least four LMS 10 samples, the copy of CV64. Anyway, even due to the supply difficulties for many parts, the production of Rotterdam sets was limited to few units.

The early experimentation was soon followed by a design review based upon parts easily attainable with German technologies. In the Berlin FuG224 the big magnet was replaced by an electro-magnet driven by a controlled current and the klystron in the receiver was replaced by a small CW magnetron, the RD2Md or the RD2Md2. By early 1944, the Berlin A of entirely German design was ready for production. But after the invasion of Normandy the war was at the door. German industry suffered accurate bombardments every day, mostly directed by X-band Allied radars. Sanitas, the major supplier of magnetrons, was destroyed and the same Telefunken plant at Schulze-Wechsungen was damaged by air bombings. Telefunken average production of LMS 10 was very low, around five units per month. At the end of the war, few hundreds Berlin 10-cm sets had been built, with an estimated production of LMS 10 around a thousand units.

Actually LMS 10 is the only German multi-cavity pulse magnetron really known until today. Samples of other German magnetrons recently found in US reveal the state of art reached in that country before the end of war. The samples were captured by American troops and stored somewhere in Washington for a long while. They came back to light in 2018, still with their US War Department identification tags dated 1946, after more than seventy years.

Very few was known on the 3-cm German pulse magnetrons. In January 1944 Germany learned of it, after the capture of an American X-band set from a crashed plane near Meddo, a small village in Holland. We do not know whether the magnetron in their hands was the 2J21, used in the early APS-4 sets, or the strapped 725A already released at the date. In this case Telefunken decided to build a 3-cm magnetron to its own design, shaped as tubular stepped cylinder. Early samples were delivered around August 1944. At first glance its shape could suggest that it was intended to be operated in the magnetic field generated by a coil surrounding its body. Actually we know that the 18-resonator system was mounted transversely to the axis of the tube, as in the image below.

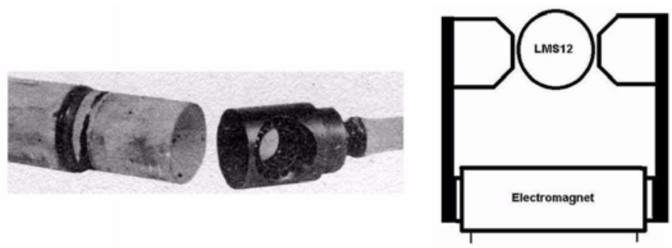


**Fig. 2 - Left, the internal construction of the new family of German magnetrons. Right, hypothetic shape of the low-mass tapered electromagnet polepieces.**

Cathode and anode were preassembled on a ceramic support before inserting them into the upper sleeve. The sleeve was brazed to the bottom subassembly. German design did not require the gold seal used in the early British magnetrons. No cooling radiator was provided, heat being transferred by conduction to a radiator in the external mount. Also optimized was the mass of magnet polepieces, tapered to concentrate the magnetic flux just in the region between cathode and anode.

LMS 12 was used in a few tens of the 3-cm Berlin-D and in some experimental ancillary upgrades for other UHF sets. Telefunken also designed scaled-down versions. One of them was the LMS 13, operating at 18.5 GHz. It never went into production and therefore did not reach operational use. The samples of LMS 12 and LMS 13 German magnetrons are so rare as to be considered the only ones existing today.

## LMS 12 - Telefunken 3-cm multicavity magnetron.

Not known the influence of the captured Meddo set on the decision of designing it. Certainly it radically departs from the designs of LMS 10, that was the exact copy of the British 10-cm CV64, and of any other magnetron used by Allies. The resonating system of LMS 12 embodies 18 cavities, while British and American X-band magnetrons were 12-cavity designs. Likely the decision of using the 18-cavity resonating system was taken to operate in a relatively low magnetic field. Its shape vaguely resembles a British micropup triode. The magnetic field was probably generated by an electromagnet, since we know that the cobalt needed for strong magnets was unobtainable in Germany at the time.


**Fig. 3 - This is the only known sample of LMS 12. On the glass bulb also its experimental code, LM 566/3, is well visible. It still retains the US War Department classification tag, dated 1946. The rod on the left looks to be the center conductor of the coaxial output. The two heater/cathode pins are on the right of the large glass bulb. Click on the image to enlarge.**

Looking at the few summary data available for this device, we note that its efficiency was quite poor, somewhere above 5%. This could derive from spurious resonating modes caused by the high number of resonators. We know that the first 3-cm magnetron developed at MIT in the summer of 1941 was based upon an 18-cavity anode block. It gave 5 kW peak power but Fisk in his article on the BSTJ, April 1946 reports ‘the design suffered from a confusion of many modes in the resonator system...’.

## LMS 13 - Telefunken 1.5-cm multicavity magnetron.

No doubts that LMS 13 is an extremely rare and fascinating witness of the progress made in a few months by Germans in the microwave power sources. It looks to be a scaled-down variant of LMS 12 and is rated for 5 kW peak at 18 GHz. Similar shape and similar internal resonating system but smaller in size. It was first announced at the end of July 1944 and likely samples were delivered soon later. It was reported as being in pre-production, with a planned capacity of 10 units per month at the end of the war.

**Fig. 4 - LMS 13 sample still retaining its US War Department classification tag, dated 1946. 5 kW at 1.625 cm wavelength. 18-resonator anode system. Click on image to enlarge.**

The above described specimens are completely different from all the multi-cavity magnetrons of British or American origin made during the war. Their interest, as well as in their extreme rarity, derives from the fact that they allow us to learn the novel German way of approaching their own design. Certainly their shape is unique and it was never replicated later, at least in the western world.

## RM 4025 - 3-cm split-anode, internal resonator magnetron

Actually this is a split anode magnetron, worth of mention here because of the many unanswered questions about the reasons why it was intended for and about its dating. Although very late, the RM4025 reveals another kind of split-anode design, similar to the one described by G. R. Kilgore of RCA in 1936. In this structure the resonating system is self-contained, to keep losses as low as possible. RM4025 was designed by Siemens & Halske, being in a quasi-experimental phase at the end of the war. The sample in the photo below looks unused, with an US War department label that indicates in 1946 the date when it was classified.

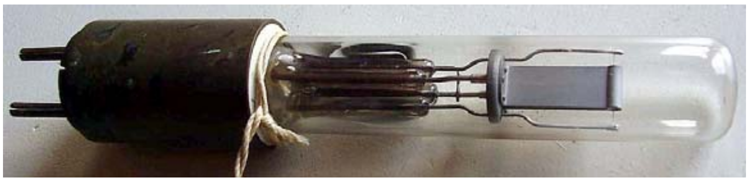
**Fig. 5 - Siemens RM4025 looks to be a split-anode magnetron with self-contained resonating system. It was designed for operation at 3 cm. Still in evaluation phase at the end of the war. Click on image to enlarge.**

The purpose of this magnetron is hard to guess. Likely the bulb is hard glass, with long X-shaped press which supports the tiny filament and the self-contained resonating system. Its overall dimensions and the size of the internal system are typical of low-power CW devices. On the contrary, the few data available, 2 kV and 4 A max anode ratings, talk of power levels not compatible with its apparent heat dissipation capabilities. We can only think it was designed either for high-duty pulsed mode or for CW mode, with power limited to a reddish coloration of the anode. The resonant frequency of its internal system is fixed, excluding any reasonable use in many kind of applications, jammers or local oscillator in microwave receivers. Likely it was intended for a kind of active guidance system or for pulse modulated telemetry, designed to operate at maximum input power around 10 watts average. Unfortunately these are just conjectures, since no info can be found even on the dates in which this device was designed. CIA reported a small after-war production in USSR at Institute 160, Fryazino.

**Last edited on January 21, 2019 by Emilio Ciardiello**
**Samples in the photos from the ase-museoedelpro collection.**