Split-Anode Unknown German Magnetron

This new arrival is definitely intriguing. Split-anode magnetrons of the type first described by Habann were quite common in the mid-1930s. A comprehensive description of them is given in a Telefunken Technical Bulletin (*1) which also shows photos of some types in production in 1934. Anyway our sample shows many details suggesting construction techniques and solutions matured over years of experience and therefore only available from 1940 onwards.

The magnetron measures about 13 cm, including connecting pins. The bulb is quite large at the bottom, about 3 cm diameter by 6 cm length, then the diameter shrinks to about 2 cm in a transition segment, 1 cm long, and terminates in a dome, 15 mm diameter by 20 mm length, this last containing the magnetron proper. The glass of the dome is sealed to the lower part of the bulb more or less halfway of the transition segment. Getter darkens about 45 mm of the bulb bottom, up to an internal metal baffle. Three rods, 1.5 mm thick, enter from below, cross the entire widest segment of the bulb and support the entire electrode system: the two ends of the filament and the center of the resonant line.

-Fig. 2 - Detailed view of the glass bulb at the transition between the large bottom chamber and the top dome containing the magnetron electrodes. The glass seal is clearly visible. Also visible the figure '44' punched on the metal baffle at left and a glass spacer across the output line at right.

The internal electrode structure recalls the one intended for higher frequency applications illustrated in fig. 23.4 of ‘High Frequency Techniques (*2), with self-contained back loop, the anode supply rod being welded to its central node, as in the draft below.

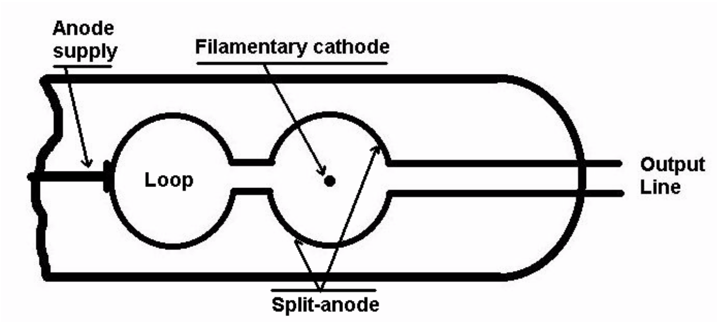

Fig. 3 - Approximate drawing of the internal anode-line assembly.

The drawing above is greatly enlarged: Actually the anodes and the back-loop appear as two similar cylinders, each measuring about 5 mm diameter by 6 mm height. The cathode is a filament, likely thoriated tungsten, of about 0.20 or 0.25 mm diameter.

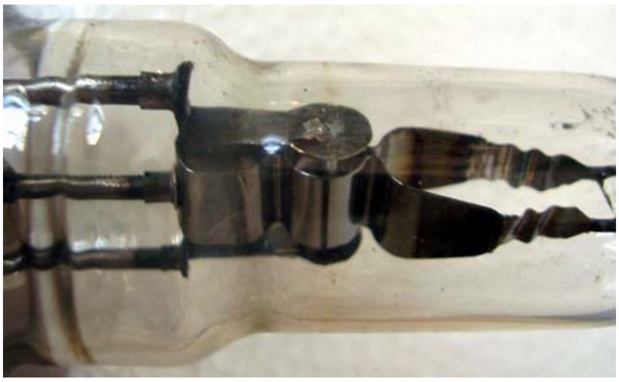

Fig. 4 - Detailed view of the anode-line assembly. Noteworthy is the termination of the three rods to which the blades that hold the filament and the center of the back-loop of the inner line are fixed. Rods are welded inside rivets fixed to the supported elements. We can observe similar solutions into another Siemens magnetron to -P.T.H. design, the RM4025,

The visual inspection reveals some unusual details:

1. The considerable extension of the getter, covering about three quarters of the internal wall in the lower and widest segment of the bulb. Such a large surface can be usually found in power tubes, such as audio or transmitting power amplifiers. The getter chamber is separated from the electrodes by a baffle, tied to the central rod and therefore raised to the anode supply voltage.
2. The neat welding line that connect glass of the lower chamber to the top dome of the bulb, which suggests the use of different glasses, maybe pyrex or other heat-resistant glass for the top end.
3. The connections of the internal line towards the top of the tube are wavy, as if to lengthen their thermal path and allow them to cool before reaching the glass wall. A glass spacer, well visible in fig. 5, is added near the end of the strips, likely to strengthen the structure and dampen possible vibrations.

Fig. 5 - Close-up view of the internal resonating line strip, connected to the outside by means of wavy sections rigidly interlocked by a glass spacer

The visual observation suggests that it is a split-anode magnetron, therefore of a quite old-fashioned type, designed and optimized to operate at rather high temperatures and therefore capable of dissipating estimated mean power somewhere around ten watts. The execution is very accurate, with construction details typical of the forties, yet it departs from the bandwagon of usual multi-segment Telefunken magnetrons. From the size of the internal system, the minimum wavelength can be estimated around 7 cm, therefore compatible with a possible use around 3 GHz.

Almost certainly the filament is thoriated-tungsten, about 10 mm length by 0.20 or 0.25 mm diameter. We can roughly estimate its emission considering that such a filament was usually operated around 1.800º K, but could be overheated around 2.000 or even 2.100º K for increased emission, of course at somewhat shorter life (*3). Assuming a surface of approximately 6 square mm, our filament could grant an emission of 50 mA at 1.800º K, rising to some 170 mA at 2.000º K and to over than 200 mA at 2.100º K. In CW operation we could then expect output power of a few watts, while in pulsed operation at 1 kV plate voltage peak power output between 10 and 50 W could be expected, depending upon the duty cycle. Of course the mean input power should never exceed a few watts, due to the tiny electrodes and to the need of dissipating internal heat almost entirely by radiation.

Now let us try to guess when and why this odd magnetron was designed and built. We told before of some details which show that our sample was built well after 1940 by a large and skilled industry, likely Siemens. Some of the said details lead us to believe that it was intended for operation at high temperature, therefore as transmitting tube. Excluding that it was designed for a microwave communication link, we could then investigate on its probable use in a navigation system or in a short-range radar, such as a fire control one, or even in radar jammers by analogy with similar American sets, as the AN/APT-4. Looking at the lists of the WWII German radars and related sets, we see a couple of radar jammers designed by Siemens in 1943, one of them using in its first version a 4 W magnetron. Very few data can be found on the Siemens FuMS11 Roderich jammer.

‘Die deutschen Funkstörverfahren bis 1945’ (*5) gives few details on this set, making confusion between variants. It gives the figure of only 4 watts as ‘pulsed power’. Telefunken RD 2Me was rated for 10 W CW and about 50 W pulsed. Maybe the book refers to minimum power at maximum expected pulse repetition rate. We just learn that some units were certainly built, since it had gained the code FuMS 11.

'It was developed in a Schnellaktion *(* this means that it had to be ready within a few weeks from the start in February 1943)* ***after the capture of the Rotterdam device, with a German magnetron (RD 2Me) placed directly in the focus of a 3 m parabolic mirror and tuned in the 2.86-3.16 GHz range. However, with a pulse power of 4 W, the transmitter was far ineffective and was therefore probably never used.',*** **adding then:**
'The Roland jammer, also by Siemens, first used a magnetron LMS10, later a disc triode LD72 (or LD75?)'*but we learn from the AGR reports that also the Roderich J was equipped with the same tubes.*

Today the reports of the AGR (*Arbeitsgemeinschaft Rotterdam*) committee are the only reliable source of information I found on the radar ancillary sets developed in Germany during the second war. The AGR committee was born early in 1943, after the capture of a British H2S 10 cm radar set near Rotterdam, to coordinate the developments of German microwave components and radar sets. Although with few details, they give information on the sets in development and on the parallel release of the electron tubes necessary to obtain the expected performances.

We learn then of the P.T.R., acronym of Physikalisch technische Reichsanstalt, which proposed several magnetrons of its own design. We also learn that the Telefunken RD2Me, six-segment magnetron, was probably sampled only in May for the Roderich jammer under development at Siemens. In the following months, due to severe delays in the delivery of the Telefunken magnetron, P.T.R. proposed once again its own design. Siemens undertook to carry out tests with this magnetron and to evaluate which type to use in production. The Tube Development Group approved a second source for this critical component of the jammer. Almost certainly then our sample is the only evidence still surviving today of the magnetron hastily built by Siemens in 1943 for the Roderich D jammer, according to a 1930s P.T.R. design. This would explain the very accurate manufacture combined with a rather old-fashioned geometry.

The table below summarizes the German development of the 10 cm jammers and passages from AGR reports describing the early developments of the Roderich and of the related transmitting tubes.

March 03, 1943	**A survey of CW transmitting tubes then suitable for 10 cm lists a 10 W P.T.R. magnetron, a Telefunken RD2Md (*we know that actually its power does not exceed 1 W and that the improved variant RD2Me had still to be designed for the jammer*) and the LD9 planar triode.**
May 19, 1943	**RD2Me, with 10 W CW power, is listed for the first time. Dr. Schultes from Siemens states that both RD2Me and the P.T.R. 10 W magnetrons could be used.**
June 01, 1943	**First CW Roderich ready for tests, 20 more under construction**
July 27, 1943	**Only two samples of RD2Me have been delivered for the CW Roderich D. Delivery of 15 more units is expected within the end of July, against a need for at least 300 units. P.T.R. renews its proposal for the production of equivalent tubes made to its own design. Siemens undertakes to run tests with this tube and then decide which type to use in production. Dr. Steimel for the Tube Development Group approves the decision to perfect the P.T.R. equivalent, also for the need to have a second source on such a critical component.**
Sept. 2, 1943	**The delivery of RD2Me tubes has yet to take place.**

AGR reports

- Report no. 2, March 17. 1943

3. Bericht des Herrn Dr. Steimel über Dezi-Röhren-Technik unter 1o cm in Deutschland

a) Hochtaströhren für Sender

Es existieren Magnetrons bei der P.T.R. für ca. 7 cm Wellenlänge mit einer Impulsleistung von 0,6 ... o,8 kW.

Die P.T.R. benötigt als Zulieferung von Telefunken Kathoden für die Fertigung dieser Magnetrons. Drei Musterröhren sind fertig und stehen zu Messungen zur Verfügung. Weiterhin existieren keine Hochtastmagnetrons.

Bei Telefunken gibt es eine Triode LD 9, die bei 1o cm Wellenlänge ungefähr 1o kW Impulsleistung abgibt. Ausserdem befinden sich hier noch weitere Trioden für Hochtastung in Entwicklung.

b) Dauerstrichröhren für Sender

Die P.T.R. besitzt ein für Serienfertigung geeignetes Magnetron mit Wolframkathode für 6,8 cm Wellenlänge und 1o W Dauerstrichleistung. Dieses Rohr kann ohne Schwierigkeiten bei einer Welle von 9 cm verwendet werden.

Bei Telefunken besteht ein Magnetron, RD 2 MD, für den Bereich von 1o cm und einer Dauerstrichleistung von 1o W.

Die Röhre LD 9 weist bei 1o cm eine Dauerstrichleistung von etwa 15 W auf und besitzt einen Wirkungsgrad hierbei von ungefähr 7 %. Für den 5 cm-Bereich existiert ein Magnetron RD 2 Mf bei Telefunken, 5 ... 8 W Dauerstrichleistung.

'Dr. Steimel on high-frequency tube technology under 10 cm in Germany

a) Pulsed tubes for transmitters

There are magnetrons at the P.T.R. for about 7 cm wavelength with a pulse power of 0.6 - 0.8 kW.

To produce these magnetrons P.T.R. requires cathodes as a supply from Telefunken (*probably spiral wound wires, to increase emitting surface*). Three sample tubes are ready and available for evaluation. No wide-band magnetrons exist. *Note that Telefunken at the time proposed only triode tubes that could be adapted to operate in the pulse transmitter*

b) CW tubes for transmitters

P.T.R. has a magnetron with tungsten cathode, suitable for volume production. It operates up to 6.8 cm wavelength, delivering 10 W continuous wave output. This tube can be used at 9 cm wavelength without any problems.

Telefunken have the RD 2 MD magnetron for the range of 10 cm and a continuous wave output of 10 W (*probably with the filament overvolted, since in March the RD2Me was still to be announced).'*

- Report no. 4, April 19, 1943

Jammer

Mr. Df. Schultes (Siemens) reports that the main difficulty with these problems is to be found in the question of tubes. A continuous wave magnetron from the PTR with a power of 10 watts or one from Telefunken with the same power could be used. The modulation is done by noise or pulses. The delivery of such a jammer can be expected in 3 - 4 weeks. A PTR tube of 1 kW and the English copy tube (LMS10) are available as magnetron pulse tubes for the variant Roderich J (likely the FuMS 12-Roland), which can be delivered in 6 - 8 weeks. It is desirable to determine the final number of transmitters to be ordered as soon as possible. The production issue of the PTR 1 kW tube is handled by the tube group. (Note the close cooperation with P.T.R., which has samples of both 1 kW pulse magnetron and of 10 W CW magnetron.)

Note - Actually Schultes is confident in the Roderich design to jam enemy radar sets. He just points out its ineffectiveness against attacks by many bombers at the same time when he talks of a recent attack by 635 bombers directed by 48

pathfinders. For similar scenarios he proposes a more powerful jammer, with high-power magnetron, such the LMS10, to generate multiple reflections all around the transmitter. In the reports we could not find any evidence of the Roderich complete ineffectiveness claimed by 'Die deutschen Funkstörverfahren bis 1945'. On the contrary we read of volume productions up to 300 units per month, at least planned. Today we can only speculate on a marginal usefulness of the Roderich due to the massive migration of Allied radars to the X-band from 1943.

2. Senderöhren für Störer bei cm-Wellen

Type	RD 2 Me	RD 2 Mf	LD 9
U_h (V)	N_h 8 W	N_h 4 W	12,6
I_h (A)			1,2
U_a (V)	800...900	900...10000	9000 (Spitze)
i_a (MA)	70	60	3500 (Spitze)
Welle (cm)	9 ± 0,3	6	durchstimmbar
Feld (G)	1400...1600	2200...2400	----
Tastverhältns.	Dauerstrich	Dauerstrich	1:100
N_{HF} (W)	10	5	5000...9000
Ausführung	6-Schlitz Magnetfeldr.	6-Schlitz Magnetfeldr.	Triode Metallkeram.
Stand der Fertigung	Vorfabrikation	wenige Muster	Vorfabrikat. läuft
Firma	Telefunken	Telefunken	Telefunken

5. Störsender

Herr Dr. Schultes berichtet, dass die Hauptschwierigkeit bei diesen Prbblemen in der Röhrenfrage zu suchen ist. Es kommt ein Dauerstrich-Magnetron der PTR von 10 Watt Leistung und eines von Telefunken mit derselben Leistung in Frage. Die Modulation erfolgt durch Rauschen oder Impuls. Die Lieferung eines solchen Störsenders ist in 3 - 4 Wochen zu erwarten. An Magnetron-Impulsröhren liegt ein PTR-Rohr von 1 kW und das englische Beuterohr vor. Störsender mit diesen Röhren können in 6 - 8 Wochen geliefert werden. Es ist wünschenswert, die endgültige Stückzahl der zu bestellenden Sender baldigst zu ermitteln. Die Fertigungsfrage des 1-kW-PTR-Rohres wird vom Röhrenring bearbeitet.

- Report no. 7, July 23, 1943

8. Status of jammer development and jammer first results against "Rotterdam" set

Dr. Schultes reports that the development of the CW "Roderich" jammer has been completed and that by October 4th a monthly production of 300 jammers can be expected. The tubes are not yet available for these transmitters.

The RD 2 ME tube has so far existed in 2 samples and it is hoped that 15 test tubes will be completed by the end of July.

Dr. Scheibe points ou again that the PTR has a tube that is electrically equivalent to the RD 2 ME and offers fewer manufacturing difficulties. Dr. Schultes will test this tube in the "Roderich" jammer and in a special G.B.N. meeting it will be clarified which of the two tubes should be manufactured for the "Roderich" system.

Mr. Brandt (Tube Development Group) points out that activating a second source for the interference tubes is absolutely necessary.

8. Stand der Störsenderentwicklung und Störsendermassnahmen gegen "Rotterdam"

Herr Dr. Schultes berichtet, dass die Entwicklung des Störsenders "Roderich" abgeschlossen ist und am 4. Oktober mit einer monatlichen Fertigung von 3oo Störsendern gerechnet werden kann. Für diese Sender stehen die Röhren noch nicht zur Verfügung.

Die Röhre RD 2 ME existiert bisher in 2 Mustern und man hofft, bis Ende Juli 15 Versuchsröhren fertig gestellt zu haben.

Herr Dr. Scheibe weist darauf hin, dass die PTR 1 Rohr besitzt, das elektrisch der RD 2 ME gleichwertig ist und geringere fabrikatorische Schwierigkeiten bietet. Herr Dr. Schultes wird dieses Rohr in dem Störsender "Roderich" prüfen und in einer besonderen G.B.N.-Besprechung soll geklärt werden, welche der beiden Röhren für die "Roderich"-Anlage gerfertigt werden soll. Anschliessend wird die Einplanung der Fertigung vorgenommen werden.

Herr Brandt weist darauf hin, dass unbedingt eine Zweitfertigung der Störröhren erforderlich ist.

- Report no. 8, September 2, 1943

8. Status of microwave tubes

RD 2 Me

The tubes for the production of the "Roderich" (CW) transmitters are not yet available. Dr. Steimel gives the lack of trained mechanics as the reason.

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RD 2 Me

Die Röhren für die Fertigung der "Roderich"-Sender stehen noch nicht zur Verfügung. Herr Dr. Steimel gibt als Begründung den Mangel an eingelernten Mechanikern an.

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In summary AGR reports evidence of the need for magnetrons of about 10 W derived from the P.T.R. design in order to produce the FuMS 11 Roderich jammers, although never giving details that allow identifying our prototype. Indirect confirmation comes from the following remarks:

- **Siemens had to build several hundreds Roderich jammers. We learn that they were ineffective against attacks conducted simultaneously by many airplanes guided by several pathfinder ones, as in the 'carpet bombing', but they were still useful in the case of isolated attacks, such as a submarine being attacked by a patrol plane.**
- **Telefunken was unable to deliver quantities of its magnetron for a while**
- **Siemens undertook to test the P.T.R. equivalent tube. By the way P.T.R. had been founded by Werner von Siemens himself. P.T.R. owned experience and some of its designs, likely developed in the second half of the '930s, were suitable for the specific use. The split-anode magnetron with internal back-loop had undoubtedly been investigated at P.T.R., as in the rest of the world, for its superior efficiency and stability at very-high frequencies. We find the same considerations for radar jammer applications in 'Very-High Frequency Techniques, Harvard University, Chapter 23'.**
- **A second source had been explicitly solicited for the Telefunken tube**
- **Doubts may arise from the different output coupling, capacitive for the Telefunken RD2 Me and galvanic for our sample. But if we consider the urgency of delivering jammers, we could certainly suppose that two variants were built or even an adaptation kit was prepared to accommodate the slightly different magnetron. After all, the reports show that the Roderich design was already defined between March and April 1943 but in September Telefunken magnetrons were not yet delivered. Certainly the pressing need for an alternative to the Telefunken magnetron was to have a tube already characterized and readily reproducible in volume, not to be 100% compatible with a tube still under development and not yet fully released.**

The few information I found on P.T.R. magnetron developments come from a CIOS report (*6). I kindly ask all the people who have further information, maybe books, papers, or technical bulletins from the mid thirties onwards, to contact me at the addresses below.

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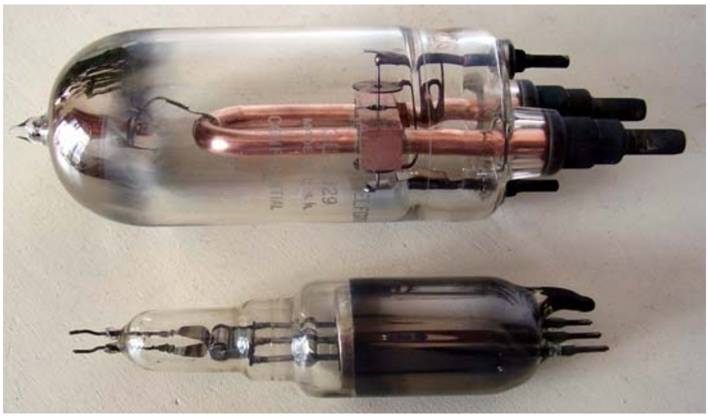
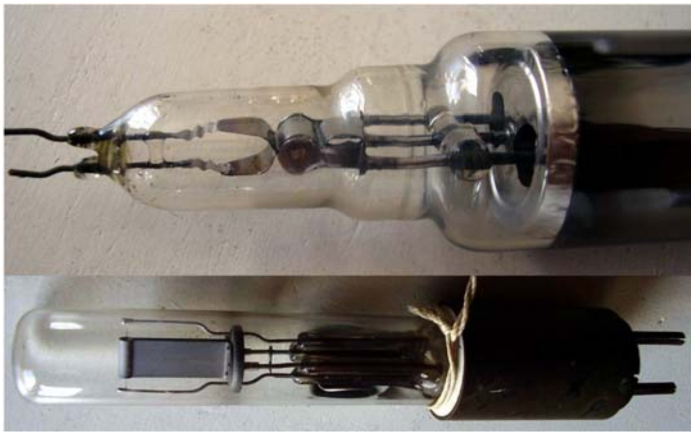


Parallel tracks in the development of magnetrons for radar jammers. Our sample is photographed below a [5J29](), the internal loop split-anode magnetron developed at the Harvard University (*2) and used for example in the radar jammer AN/APT-4. 5J29 was useful from about 350 to 770 MHz.



Our unknown sample compared with a quite late P.T.R.-Siemens RM4025 10 GHz split-anode magnetron. We can appreciate similarities even in construction solutions, such as the eyelets that firmly connect supporting and supply rods to the middle of anode structure.

Acknowledgments:

Valuable help was provided by Karl-Heinz Gollmann, who first provided us with this very rare sample and then suggested the publications on German radar jammers, also translating relevant parts from the German reports of the AGR committee, the one that was created in 1943 to develop microwave devices.

1 - Telefunken Zeitung, december 1934: https://www.cdvandt.org/Runge-magnetron.pdf
2 - Very High Frequency Techniques, Vol II - Chap. 23, Harvard University, 1947
3 - Stiles W. S. - Thermoionic emission, H.M. Stationery Service, London 1932
4 - AGR (Arbeitsgemeinschaft Rotterdam) reports: https://cdvandt.org/agr_protocols.htm
5 - Die deutschen Funkstörverfahren bis 1945, Fritz Trenkle, AEG-Telefunken
6 - CIOS report 1/441: http://www.ase-museoedelpro.org/Museo_Edelpro/temp/CIOS_1.441_PTR.pdf

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