Walter Weber's Technical Innovation at the Reichs-Rundfunk-Gesellschaft

by Friedrich Engel

Abstract:

Walter Weber (1907–1944) was one of the highly innovative engineers at Reichs-Rundfunk-Gesellschaft (RRG, German Broadcast Company). Judging from today's standpoint, his most important contribution to the development of audio technology was the implementation (not the invention) of high frequency biasing in practice. Thus at a single stroke magnetic recording became the most favourable method in sound recording, both in terms of reliability and quality. Subsequently, Weber combined magnetic tape recording and stereophony. Thus the state of recording technology at RRG was ahead of its time.

The Reichsrundfunk Gesellschaft (RRG) was founded in Berlin in 1925 and existed for 20 years, the last 12 of these as the official propaganda organ for the Third Reich. Inspite of this, however, artistic and, in particular, technical heights were attained in Berlin that determined the future of radio in Germany long after 1945. The “technical side” took the new task of presenting artistically important productions to a non-homogeneous audience surprisingly seriously. The cooperative efforts of both artistically interested technicians and technically open-minded program production staffs was certainly one of the finest legacies of the RRG.

A scientist noted for his “extraordinary breadth of knowledge and great musical talent” joined the RRG in 1930: Hans Joachim von Braunmühl, later to become the RRG Electroacoustic Laboratories Chief Engineer. Shortly after joining the firm, he brought a young engineer he had met at the Siemens und Halske AG Central Laboratory, Walter Weber, to work with him. For the next 14 years, the two men's cooperative efforts would prove to be unusually productive. Looking back, it is hard to determine how much of the intensive efforts were specifically attributable to one man or the other. We must assume, though, that von Braumühl's repeated assertions that Weber was responsible for the development of the Magnetophon were, indeed, true.

Walter Weber was born in Gelsenkirchen in 1907. He received his initial technical training from 1925–1927 at the Ingenieur-Akademie in Oldenburg. After two years with Siemens und Halske, he transferred to the RRG. His education continued parallel to his regular duties, and he completed his O-Levels by Easter, 1932, before studying three semesters at the Charlottenburg Technical College and four semesters at the University of Berlin. In 1938, he was awarded his doctorate, having been mentored by the respected acoustic scientist Friedrich Trendelenburg[1]. Von Braunmühl described Webers dissertation as “... an especially valuable work that gained the attention of many colleagues”.

Initial Work at the Reichsrundfunk Gesellschaft

What appears to be the beginning of a promising career, such as development of the dual tone measurement method and publishing the article “Disturbances Caused by Non-Linear Distortion”,[2] were really only two of Weber's many efforts on behalf of the RRG. The latter is of particular interest due to the difficulties arising from the subjective nature of the topic. In 1935, Weber developed an condenser microphone with switchable[3] omni-directional and cardioid directional characteristics that would later be built by the Berlin company, Neumann.[4] He may have developed the measurement techniques used in his dissertation at that time. It is easy to imagine that the team of von Braunmühl and Weber was only able to complete its next project in 1936 after, as they reported, “many nights of too little sleep“: Their book, “Introduction to Applied Acoustics, Especially Pertaining to New Problems in Sound Measurement, Transmission and Recording”[5] would “soon become the standard text for everyone working in broadcast technology”. Chapter 5, “The Sound Recording Process”, closes with the following prophetic words:

> *“It has recently become possible to replace expensive and heavy steel tape with a film-like sound carrier backed with a magnetizable coating. It would appear that simultaneous improvements in the [new] tape quality and reductions in the size of the apparatus will permit magnetic sound recording to be used for new tasks.”*

These words basically set Weber's efforts into motion for the next decade.

Fig. 1: Walter Weber (1907 – 1944)

Courtesy Dr. Jörg Weber, Berlin

The Sound Recording Methods at the RRG

It should be remembered that from the earliest days of radio, programmers were aware of the advantages that recording offered. Von Braunmühl listed the most important uses:

- *to record rehearsals to instruct performers concerning errors in their presentation;*
- *to check reports prior to broadcast, especially for censorship purposes;*
- *to broadcast programs at sites without program lines;*
- *to playback performances at times when the majority of listeners can hear them in stead of at the pre-determined time of performance;*
- *to make better use of prominent performers who have other commitments during the primary listening times;*
- *to repeat broadcasts which, due to their importance, deserve to be broadcast several times;*
- *to exchange programs with other broadcast organizations by shipping sound carriers instead of requiring land lines;*
- *to archive valuable recordings for future generations.* [6]

The pressure on technicians to discover an ideal means of recording was correspondingly powerful. None of the then-known processes (wax records, the Lorenz “Stahlton-Bandmaschine” (steel tape machine), sound foil, sound film and the lab-tested mechanical-optical Philips-Miller procedure) were adequate.

Magnetic Sound Recording at the RRG: The Beginnings

In 1936, the scepticism shown towards magnetic recording was understandable; the few steel wire machines on the market barely achieved dictation quality. The steel tape machine, “Stahlton-Bandmaschine”, built in 1934 by Semi J. Begun at the Berlin company, C. Lorenz[7] provided broadcast quality, but its enormous weight and horrendously expensive steel tapes, imported from Sweden, far outstripped the operational advantages over wax records. A playing time of 30 minutes and less sensitivity to vibration were desired, but not on those terms[8].

The “Magnetophon” was introduced at the German Broadcast Exhibition in Berlin, 1935. It was a co-development of AEG, Berlin and IG Farben, Ludwigshafen, today better known as BASF[9]. The relatively light and inexpensive “Magnetophon K 1”[10] machine and the grey “Magnetophonband Type C” (costing only one seventh the price of steel tape) naturally caught radio's attention and was tested in the RRG's laboratories. But, the newcomer was marketed as a dictation machine and its loud background noise and obvious distortion, despite use of Poulsen's DC biasing, caused the RRG to reject it as unacceptable. This remained the case till 1936, when further developments in tape and machine made a second test worthwhile. In 1938, the RRG was the world's first broadcaster to introduce the Magnetophon into service

on a test basis. The sound quality, at the time, was approximately equal to that of sound foil. RRG and AEG together developed the broadcast machine HTS, RRG designation R 22, based upon the Magnetophon K 4.

Unfortunately, a large portion of the RRG technical files were destroyed after the war so that the final decision in favor of Magnetophon cannot be reconstructed in detail. Von Braunmühl reported, however, that Walter Weber was the “driving force, involved in all advances” of development, something confirmed by a long list of patents and patent applications which accompany the Magnetophon's decade-long development process.

Improvements in Magnetophon Dynamic Range

Of primary importance was Weber's attempt in late 1937 to improve dynamic range, and thus quality, independent of AEG. He assumed that the uneven magnetic tape coating (both mechanically and magnetically) would cause irregular fluctuations in the magnetic flux in the record head, inducing unwelcome signals and therefore increasing the noise. By bridging an active record head to a dummy head (Fig. 2), the negative feedback voltage was to be returned to the recording circuit via an amplifier[11]. The resulting 3 dB noise reduction was certainly no breakthrough. However, by also factory-smoothing the tape coating surface, another 3 dB were gained, creating a more acceptable 6 dB improvement.

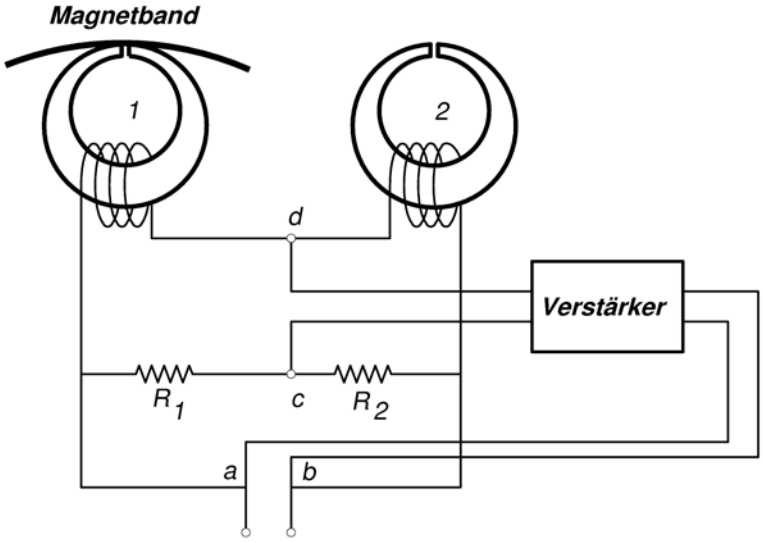

Fig. 2: Weber’s experimental circuit for noise reduction via negative feedback: 1 active magnetic recording head, 2 ”dummy” head; Magnetband = magnetic tape; Verstärker = amplifier. The bridging voltage occurring at d and c – the difference in voltage between heads 1 and 2 – would be amplified and act as a negative feedback, thus decreasing the tape-induced noise in the recording process

Negative feedback and push-pull processes are common means of improving amplifiers' efficiency. In this vein, Fritz Pfleumer, the actual inventor of magnetic tape, had already tried recording using a push-pull technique although without noticeable success[12]. The most creative mind on the AEG Magnetophon team, Eduard Schüller, replaced the unreliable transducer used by Pfleumer with a two-track version of his own invention, the ring head which had the special advantage that both gaps were exactly aligned[13]. The tape width was now divided into two recording tracks (see also Fig. 7).

Using the two-track ring head, Weber attempted something analogous to modern loudspeaker construction: he divided the frequency range to be recorded into two bands and recorded each component on a separate tape track[14]. This had the advantage, to use modern terminology, of allowing him to adjust (DC) bias individually and minimize noise by adjusting the equalization. In any case, as Ernst Augustin, Weber's later partner, dryly commented, what mattered was, “the desired result, ... not the means needed to achieve it”.

Nonetheless, the Magnetophon had the potential to both expand and to simplify radio broadcast operations while making them more reliable, in the process. Attractive advantages were:

- the 20 minute playing time of a 400 gram (approx. 1 pound) tape compared to a wax record weighing ten times as much, but with a playing time of only four-and-a-half minutes. Additionally, these re-

cordings could, with good conscience, only be played once (and even then, only with an electro-magnetic pick-up co-developed by von Braunmühl in 1932[15]);

- the ability to immediately playback a recording, even directly from the playback head (although this was never mentioned);
- the re-usablity of magnetic tape by erasing unusable or unneeded recordings;
- easy editing, as with films, to remove or re-arrange portions of the recording.

Still, as Weber wrote, "... the process was not especially well received and its use in broadcasting was, therefore, low. The Magnetophon's high level of background noise made all other advantages moot".[16]

"High Frequency Treatment" Improves Dynamic Range

Perhaps it was this challenge that drove Walter Weber, a typical research-oriented personality, to re-examine experiments with negative feedback, probably in mid-April 1940. At some point during the series of experiments, a minor accident occurred in the laboratory; apparently a simple mistake, otherwise easily corrected and forgotten. Its unexpected effect, however, was noticed, analyzed and placed into practice by the creative genius. Weber described it thus:

> *"While experimenting with negative feedback, the test circuit began to oscillate under high degrees of feedback. When oscillation began, a dramatic decrease in background noise was observed. ... The first experiment ... [noise reduction using high frequencies] was conducted merely combining high and low frequencies together at the recording head. It was expected that the low frequencies would be missing from the recording, but this was not the case. On the contrary, the lower frequencies were very clean and recorded with a much lower noise level. Tests showed a noise reduction of 10 dB with a nonlinear harmonic distortion coefficient reduction from 10 % to 3 % with the same voltage on the playback head as reference. This phenomenon was further developed and resulted ... in an entirely new recording technique. ... Expanding the frequency curve to 10 kHz, a dynamic range of 60 dB was reached with a distortion factor of 1.5% at 1,000 Hz".*[17]

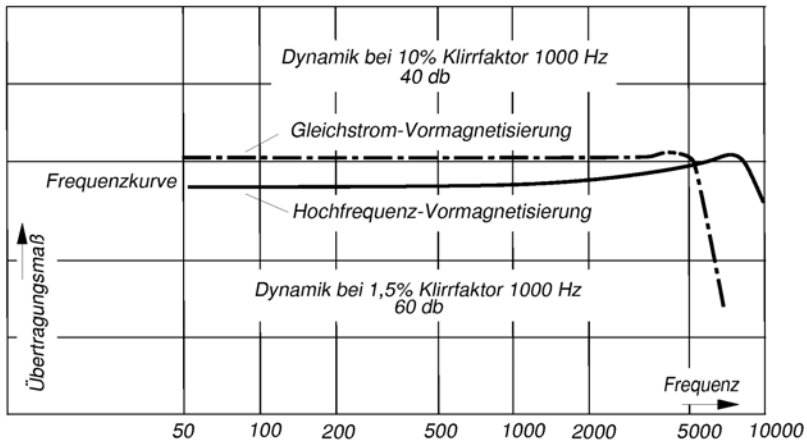

Fig. 3: Frequency response and dynamic with DC bias ("Gleichstrom-Vormagnetisierung") und AC bias ("Hochfrequenz-Vormagnetisierung"), showing also a significant reduction of distortions from 10 % to 1.5 %[18]

This means: Weber first found an amazing improvement in "noise reduction" of about 10 dB. Furthermore, HF biasing dramatically improved the tape's recording properties at high audio frequencies, giving the opportunity to re-design the record equalization circuit resulting in a further improvement in dynamics of about 10 dB. With DC bias, the frequency response of the recording amplifier above about 3 kHz had to show a sloping characteristic. Using AC biasing, a part of the necessary high-frequency gain can be carried out by the recording amplifier. This reduces the amount of high-frequency gain in the playback amplifier – which inevitably raises the tape noise, too –, resulting in improved dynamics.

For Weber and his supportive supervisor, von Braunmühl, it was clear in July, 1940 that they had so dramatically improved the Magnetophon, "that playback quality now far exceeds that of any other recording process". Within ten months, the first prototype was ready for operation. This delay was not caused solely by the outbreak of the Second World War the year before. First, the positive operational conditions had to be determined; in other words methods of establishing the optimum bias and adjusting

the equalization had to be found. In any event, these initial ideas in cooperation with AEG became the basis for a new generation of machines, the tape recorder R 22 and its accompanying amplifiers, and tape recorder R 26, as mentioned elsewhere[19]. The result: “No other operational work process has ever been so quickly and enthusiastically accepted, in particular by the programming staff”. By 1944, German broadcasting, “is unthinkable without high frequency Magnetophons”.

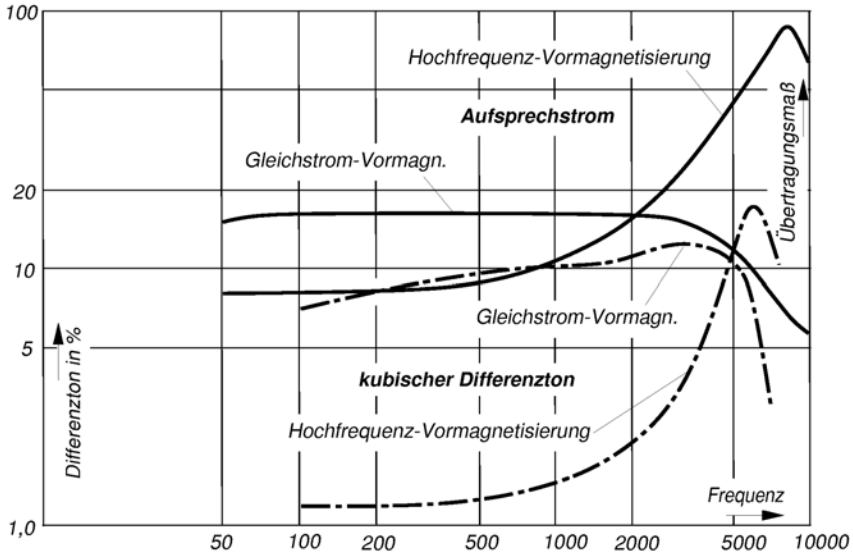

Fig. 4: Frequency repsonse of recording amplifier and spektra of distorsions at DC bias (“Gleichstrom-Vormagnetisierung“) und AC bias (“Hochfrequenz-Vormagnetisierung“)

Thus, it was three men from Berlin who were primarily responsible for perfecting the magnetic tape recording process: Eduard Schüller of AEG built the machines; the native Berliner Friedrich Matthias developed and made the tape at IG Farben in Ludwigshafen; and Walter Weber, from the Berlin House of Broadcasting, was responsible for creating four decades of matchless recording quality thanks to the high frequency biasing process.

Fig. 5: Magnetic tape recorder “Magnetofon R 22” of about 1939, customer built by AEG for RRG (German Radio). Tape speed 77 cm/s (approx. 30 ips), tape width 6.5 mm (approx. ¼“), playing time with 1.000 m of tape around 22 min

Patents and First Applications

In February, 1941, von Braunmühl and Weber signed a licensing agreement with AEG Berlin for a total of six patents [20]. Among these was an idea for magnetic sound recording in place of optical sound on sprocketed film, a forerunner of later magnetic film recording techniques. The most valuable suggestion proved, understandably, to be “High Frequency Treatment of Magnetogramm Carriers”, later to become Patent DE 743 411[21]. Thus, it was AEG that presented the “new magnetic sound recording process for especially noise-free, high quality sound recording and playback” at the Berlin movie theatre equipped with the best PA system, “Ufa-Palast am Zoo” on June 10, 1941. The trade press wrote enthusiastically about the recording quality (“The highest quality electrical recording process... it will result in the complete revolution of sound recording“) and spoke of a technical procedure for “high frequency treatment of the sound carrier during the recording” or “high frequency influence of the sound carrier”. Richard Schmidt (FTZ, Filmtechnische Zentralstelle) was to report on the “Applications of the Process in Sound Film” at the Ufa-Palast, in which he would explain, “that it's main purpose is in the production of primary [master] tapes. These tapes and the operational advantages of magnetic recording help make film production easier...”.[22]

The “HF Patent” DE 743 411

The chaotic natural law requiring everything worthwhile to be invented twice is confirmed repeatedly in the history of magnetic tape technology. The magnetic recording process was first formulated in 1878 by Oberlin Smith[23] and first demonstrated twenty years later by Valdemar Poulsen, when he also mentioned a method to produce something like the modern magnetic tape (1898)[24]. It was Pfleumer, however, who received German Patent DE 500 900[25] (“Lautschriftträger”, “Sound Recording Carrier”, filed 1928) in 1930 but whose patent was nullified in 1936 when it was discovered that an American named O'Neill[26] had patented the basic idea (although in a non-workable form) five weeks earlier than his German counterpart.

It should come as no surprize, then, that, strictly speaking, by 1940 “High Frequency Treatment” was hardly a new idea. Without going into details, mention should be made of the American patents awarded to Carlson / Carpenter[27] and Alverson[28] (although the latter recommended using modulation instead of heterodyning). The Japanese Igarashi, Ishikawa and Nagai were also awarded a patent in 1938[29]. For this reason, it is no longer possible to determine how HF Patent DE 743 411 could have been awarded, again. In all probability, Weber made his discovery independently and first learned of these predecessors during the patent approval process. Unlike the others, though, Weber and von Braunmühl were the first to recognize the true potential of their findings, as can be seen by the rapid series of patent applications in wide-ranging areas during the fall of 1940. Secondly, and more important, they did what was necessary to make their developments quickly and effectively practical to as wide an range of users as possible. It is in this respect that historians see their most valuable efforts.

The irony of technical history is such that still another man of comparable importance, Marvin Camras in the USA, also invented the concept of HF biasing, this time in late 1941[30].

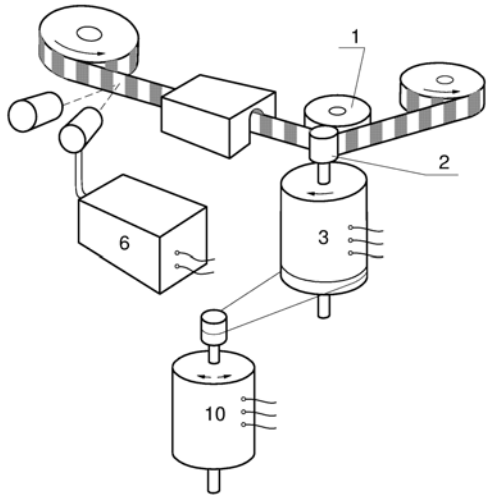

Fig. 6: Weber and Augustin: Synchronisation between film and magnetic tape by means of "sprockets" printed on the back of the tape[31]

Synchronization of Magnetic Tape and Film

Working together with E. Augustin, who had left the RRG to join the TOBIS film company, Weber continued to explore synchronizing magnetic tape sound with film. This led to two patent applications in 1943. Unlike previous magnetic film recording machines, which had first been patented in 1941[32], the new attempts were with non-perforated material using "an optical, magnetic,or mechanical carrier frequency from the sound medium" to maintain synchronization. Drawings show a magnetic tape with light and dark stripes printed on the backing[33], much like tapes still used in the 1970's to synchronize tape machines. The recommendation that "magnetic impulses recorded alongside and in addition to the actual sound recording" can clearly be seen as the precursor of the pilot tone recording process.[34]

Stereophonic Recording

As early as June, 1941, a report concerning the Ufa-Palast presentation mentioned that the high frequency Magnetophon process could also be used to produce stereo sound and, according to UFA notes,[35] the RRG was able to present stereo recordings in late 1941. An American report made after the war[36] appears to confirm this. The report indicates that the machine used was an RRG R 22a with recording amplifiers (in pairs) V 5 and playback amplifiers V 7b. Judging by the meagre information available,[37] however, it was not until 1942/43 that real stereo-capable machines were operational, based on a Magnetophon K 7 with a synchronous capstan motor and two-channel recording and playback amplifiers using separate power supplies. After initial in-house presentations of "space depth recordings" at the RRG in January, 1943, these presentations were made public at the end of April,[38] simultaneously demonstrating the wide spectrum loudspeakers newly developed by the RRG Engineer Hans Eckmiller.

The critical components of the stereo Magnetophon were the two-track heads that Weber had AEG develop from the "twin head" he had used in his two-track recording experiments. To reduce crosstalk, a one millimetre separating track was required, created by building a brass strip into the head. This meant that the 6.5 mm wide tape (a little bit wider than quarter inch) was then divided into two tracks of 2.75 mm. While a full-track recording at tape speed of 77 cm/s (30.2 ips) offered a dynamic range of 60 dB, this dropped to 42 dB on stereo recordings, although the surviving RRG stereo productions sound subjectively much better than the figures would indicate. Of the approximately 300 RRG stereo recordings made (mainly symphonies, operas and so on), only a very few tapes still exist. This acoustic equivalent of the lost "Amber Room"[39] is another of the culturally painful costs of the Second World War.

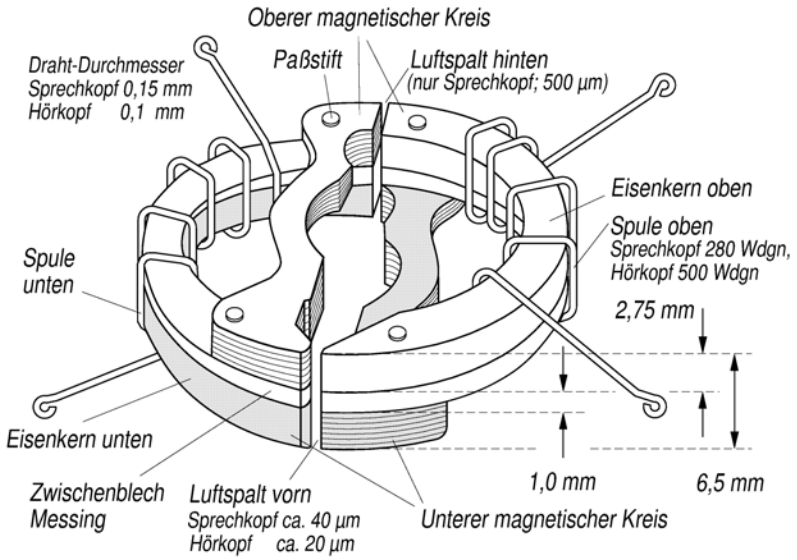

Fig. 7: Schematical representation of stereo magnetic head as used by RRG (developed by Eduard Schüller, AEG)

During the course of the war, the RRG laboratory was moved to Kosten near Posen. The employees there were stunned to receive the following notification on 20 July, 1944:

> *"At the peak of his successful endeavours, our Chief Engineer Dr. Walter Weber was suddenly and unexpectedly torn from us by death on 18 July. A vigilant spirit, a fighter for fundamental knowledge in science as well as in life, a real comrade and true friend was, abruptly and without warning, taken from his desk and laboratory at the age of 37, his notebooks still open and his machinery still running."*[40]

How did this tragedy occur? Following a meeting on the evening of July 18, Weber went for a swim but, on leaving the pool, suffered a heart attack and collapsed. A doctor was called immediately but could do nothing to save the stricken man. In a eulogy printed in the RRG in-house magazine, Hans Joachim von Braunmühl described his colleague as a universally respected man of honourable character and remarkable humility.

"During twelve years of creative efforts, he carried out an incredible amount of scientific research and technical development. These accomplishments alone already made his name nationally and internationally renowned, but it was especially in recent years that his unusually prolific idea of introducing high frequency biasing to magnetic recording led to dramatic improvements in electro-acoustical technology. Dr. Weber's name will forever remain tied with the high frequency Magnetophon, currently the highest quality means of recording voice and music. Its superb sound quality will reach circles far outside those of science, where this new means [of sound reproduction] will be implemented for artistic purposes."[41]

Acknowledgements:

Since the technical records of the RRG have, for the most part, been lost, the preceding presentation was based primarily on such publications as patent reports and articles printed in the "Reichsrundfunk" Magazine as well as on files from the AEG and BASF archives. In particular, I am especially grateful for the generous permission to use the personal files of Dr. J. Weber, Walter Weber's youngest son.

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(22) At least three dozens of press reports on this event can be shown. This is the straightforward proof to the contrary on all assertions that “magnetic tape technique was a military secret“ and inaccuracies of that kind.

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