75 years of magnetic recording

2—The dark years

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Up to about 1915 the use of valves had been extremely limited and rarely applied to the telegraphone type of recorder. However, from that date on until the mid-1950s it was to play a massive part in turning a declining technology into a brilliant new era. The dark years of World War II were also approaching to produce a remarkable dichotomy in recording media. In this article the story advances to 1945.

The combination of World War I and mismanagement of the technical development of the Telegraphone, brought about the demise of the Poulsen companies by about 1918. From then on there are only passing references to magnetic recording in the literature, mostly connected with Poulsen models or slight variants of them. As mentioned in Part I of this series, it was Kurt Stille who revived interest in magnetic recording and this through the medium of the Dailygraph, later developed into the Textophone[-6], and a steel tape machine originally conceived for synchronized film sound track.

In Britain, Stille's ideas were exploited by Ludwig Blattner, who, according to a contemporary account,[27] was a small, lively man with a keen showman's mind. He, with his engineers, developed a machine called the Blattnerphone, an early model of which was used to provide synchronized sound for demonstration films. These films were used as part of a sort of "circus show" where a public audience would come to see the "talkies" and in the intervals Ludwig Blattner, also a keen dancer, would pull ladies from the audience to dance with him on stage to recorded music from the Blattnerphone!

More seriously, the BBC took an interest in these machines and by 1931 at least one had been bought and installed at Savoy Hill (Fig. 1). This was a machine that used steel tape 6mm wide running at a speed of 1.5 metres per second with a playing time of 20 minutes. Since the drive was by d.c. motor, it suffered from wow and speed drift, which had to be corrected by operating a rheostat and observing a stroboscope attached to the capstan.

Pressure was increasing within the BBC to provide an Empire Service and since the government of the day had taken so long to produce a decision to allocate funds for the capital investment, the BBC took an independent decision to finance the initial stage and open service just after Christmas 1931. Since the long-distance transmissions had to be timed to obtain reasonable hours of reception—usually early evening local time—broadcasts were beamed by using directional aerials, with the transmitters switched to each aerial at two hour intervals. Thus, to enable a programme broadcast to Australia to be heard in Canada the material had to be available for repeat. Disc recording had not been used in the BBC up to that time, and in any case the playing time was rather limited. The Blattnerphone seemed to provide just the right answer.

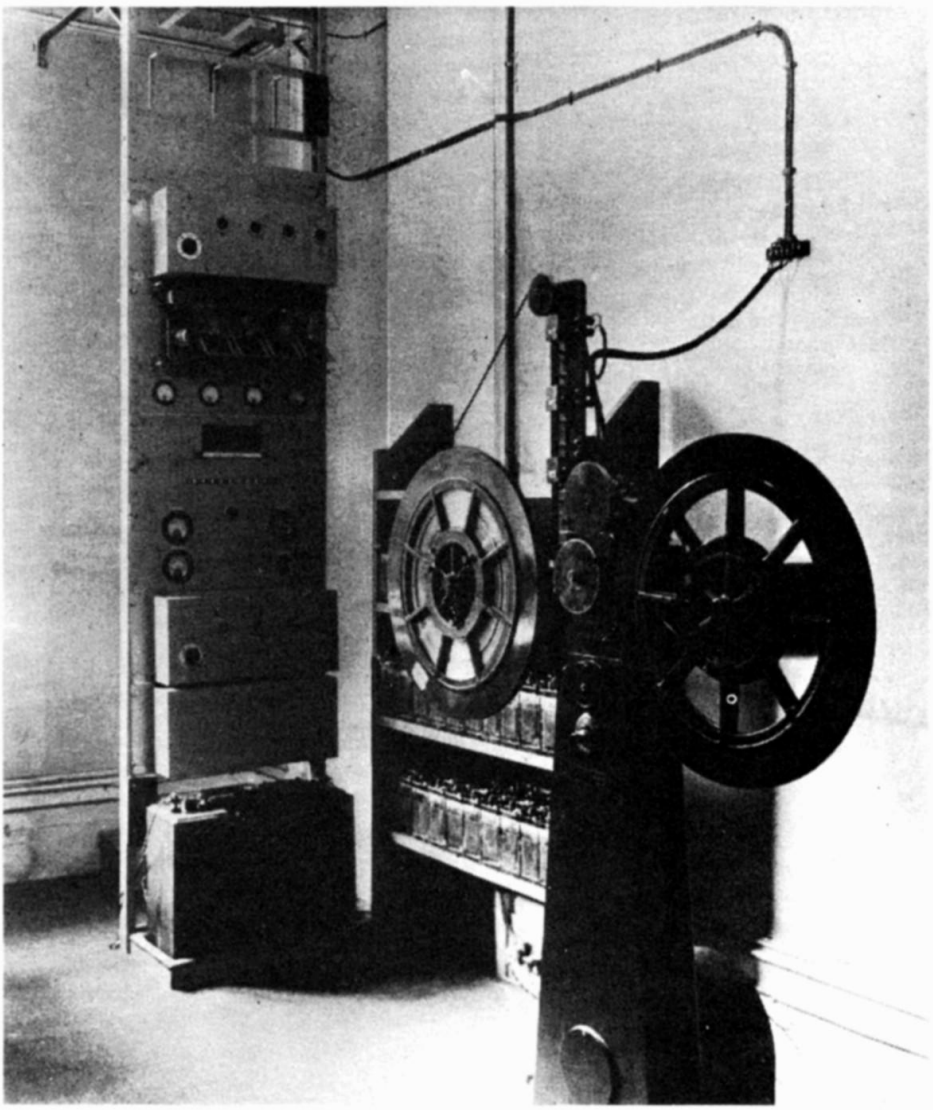

Fig. 1. An early 6mm Blattnerphone machine installed in Savoy Hill in 1931. (Courtesy BBC).

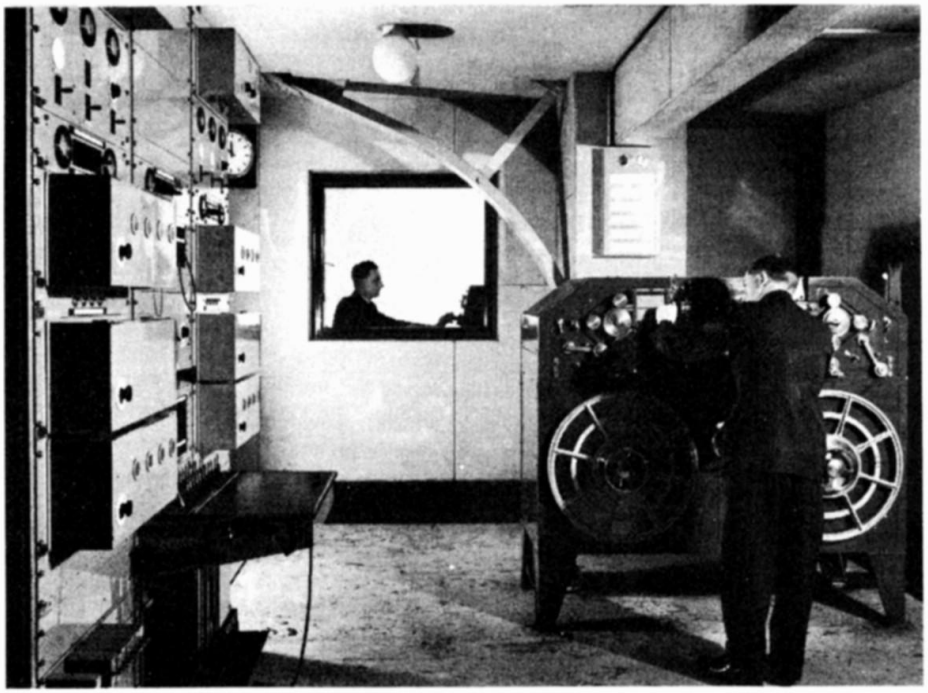

Fig. 2. A Marconi-Stille recorder installed in BBC Maida Vale studios from 1934.

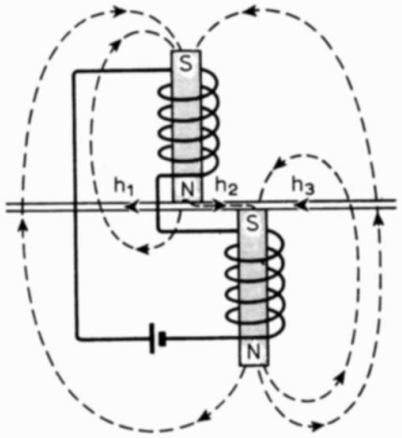

Fig. 3. The Stille erase head assembly showing the saturating flux fields.

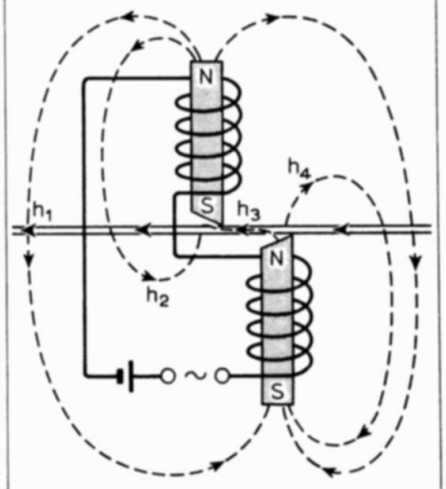

Fig. 4. The record head flux field of a Marconi-Stille machine.

Having pointed out the deficiencies in the 6mm Blattnerphone, the BBC then encouraged an engineer, von Heising of the British Blattnerphone Company, to develop a machine meeting the BBC requirements[28]. After only three months, two prototypes were produced and installed, first at Savoy Hill and then at Broadcasting House. Further technical details on these and later machines follow, but for the moment, suffice it to say that the speed stability was improved and tape width reduced to 3mm. Apart from the somewhat dangerous operating conditions, the steel tapes were also difficult to edit.

Nevertheless, it was obvious that this represented somewhat of a challenge to the engineers of the day, since several magazine programmes were broadcast during late 1932 and in 1933. One of these included a composite programme of the 1932 Economic Conference in Ottawa which was compiled from seven miles of recorded steel tape[29]. However, the fact that steel tape was a new recording medium coupled with the prospect of being able to erase the tapes made it unreliable, in the minds of the BBC, as a source of archival recordings. What confirmed this thought was that part of the first Christmas Day, 1932 feature programme was accidentally erased. Godfrey[29] goes on to say that subsequently arrangements were made, with the British Homophone Company, to record highlights onto disc from Blattnerphone tapes, the signal being fed from Maida Vale to Kilburn by telephone lines. He also remarks that this must have been the first time discs were produced from magnetic recordings.

Shortly after 1932, the Marconi Company bought rights in the Blattnerphone machine and produced a slightly lighter version which was mounted on a wooden table. By 1934 this, however, was superseded by what surely must have been one of the largest audio magnetic recorders ever — the Marconi-Stille machine. This was mechanically very sophisticated and six were ordered and installed in Maida Vale from 1934 (Fig 2). Two more were added during the war and these machines were in constant use during this period and after, the last one being taken out sometime around 1950.

A fascinating tale is told of one of the early Blattnerphones. This machine was one of the original two 3mm recorders installed at Savoy Hill and as part of the move to Broadcasting House they had to be shifted overnight. It had just been connected, though not tested, when a telephone call came through to the tape room to get a machine going, whatever it took. The switches were thrown without further ado and with, it would seem, a good deal of finger crossing, to record an historic interview with Amelia Earhart. The date was May 21, 1932, the very day she landed after an epic flight across the Atlantic.

History was to repeat itself since during 1939 it was resurrected from the embryo BBC museum to be the first tape machine installed at the dispersed BBC wartime location in Worcestershire. Once again, the same engineer, with other colleagues, had hardly completed the installation when they were told to get the machine going, this time to record the Prime Minister. The date was September 3, 1939 and the Prime Minister was Chamberlain broadcasting the declaration of a state of war between Britain and Germany[30].

This self-same machine was again resurrected to record some items for the 50th Anniversary of the BBC and now rests in a well earned retirement at Bristol City Museum, awaiting location in a new gallery.

Technical specification

The second generation Blattnerphones were driven with an a.c. synchronous motor which improved speed stability. Since this was an era before the adoption of a.c. bias, the tape was erased and biased with d.c. set from preset controls on the amplifier rack. The replay amplifier was a standard BBC type A amplifier[31], modified to permit an equalization circuit to be connected to the grid of one of the valves. A power output stage, capable of giving up to 10W, provided the loudspeaker monitoring facility. The microphone and head-driving amplifier were specially designed for the job. The Blattner machines were only fitted with three head block assemblies, the later Marconi types having five, the reason for which was not at first obvious to the author. Contact was therefore made with the engineer mentioned in the previous anecdotes, R. C. Patrick, for an explanation. It would seem that the idea originated with Patrick, who at that time was working in BBC Research. Marconi had just taken over the licence to produce the machines and had asked the BBC, as largest users of Blattnerphones, what improvements could

be made.

Editing of steel tapes was then quite common but unfortunately the actual edits, which consisted of a soldered joint, destroyed the knife-edge pole pieces of the record and replay heads. Patrick suggested that two standby heads, one record and one replay, were fitted which during operation of the machine were left out of contact with the tape. After the passage of an edit, the spare heads would then be quickly brought into contact and the damaged heads opened to permit replacement of the spring-loaded pole pieces and wait for another edit!

Of the three basic types of head assembly used, one was erase, one record and one replay. The design consisted of two simple pole pieces, solenoid wound, one on either side of the tape. The erase-head pole pieces had a flat contact surface with the tape and were made of Stalloy, also used for the record head. The assembly could be hinged open to facilitate threading.

Erasure was by saturation magnetization of the tape[31], illustrated in Fig. 3. Briefly, a direct current of about 20mA was passed through the coils connected in series. When the tape approached from the left, the field h_1 applied, the strength being above tape saturation as it passed under the first pole piece. There then followed a reversal of flux under the influence of field h_2 and finally another reversal caused by h_3. The tape was left in a saturated state in the direction of this field.

The record head was of similar construction, though the interchangeable pole pieces were this time shaped to a knife edge to improve short wavelength performance. Of the alternative arrangements possible, single pole piece or double narrow stagger, double wide stagger or double pole piece with one being idle, the BBC adopted the double pole narrow stagger arrangement (Fig. 4).

Again, the coils were connected in series and a 4mA direct current bias applied with the signal. Here the tape saturation field h_1 was reduced by field h_2, restored to saturation by h_3 and finally subjected to the demagnetizing influence of h_4. Since h_4 was also modulated by the signal the remanent flux in the tape followed the current fluctuations in the head.

Finally, the replay head used by the BBC had only one pole piece, made of Permalloy, since the setting of two pole pieces, which produced better high-frequency performance, was too critical for practical purposes.

The actual tape deck of the Marconi-Stille machine represented a considerable advance on early models with the tape drive being achieved through three motors. Tape was drawn off the feed spool by drive No. 2 and fed into a box reservoir where a loop would build up. When the earthed loop contacted a metal surface at the bottom of the box the bias was removed from the grid of a thyratron and a relay in the anode operated, to switch a resistance into the motor circuit, slowing the motor down.

The tape was drawn from this reservoir by a capstan drive, which in turn fed a loop of tape into a second, larger reservoir. Again, when the loop of tape contacted the bottom of a reservoir a thyratron operated relay would remove resistance from the winding motor circuit speeding the motor up.

Despite sterling service and a surprisingly good performance for its day, disc recording gained the ascendancy during the World War II and after 1947, the impact of plastic based tape was to sound the death knell for this remarkable machine.

Recording in Germany

Going back to the late 1920s the seeds were being sown, in Germany, of a new-old idea which, in later years, was to revolutionize the art of magnetic recording. This was the revival of the idea of coating a flexible insulated base with a finely divided magnetizable substance. An independent engineer from Dresden, Fritz Pfleumer, was struggling to develop both a recording tape which had a flexible insulated base with a magnetizable surface and also a suitable machine. Presumably his funds and resources were too limited, since although he had secured a patent[32] for such a tape (filed in February 1929), by 1930 he soon after sought the help of a German electrical company Allgemeine Elektrizitats Gesellschaft of Berlin (A.E.G.).

It is not too clear just how good a chemist Pfleumer was, since his early patent sounds rather more like a recipe for a pudding than a tape coating! In the introduction, he acknowledges that there prior inventions regarding the use of magnetizable substances on a flexible base but then goes on to describe the methods for his type of tape. I quote, ". . . a powder of soft iron is mixed with an organic binding medium such as

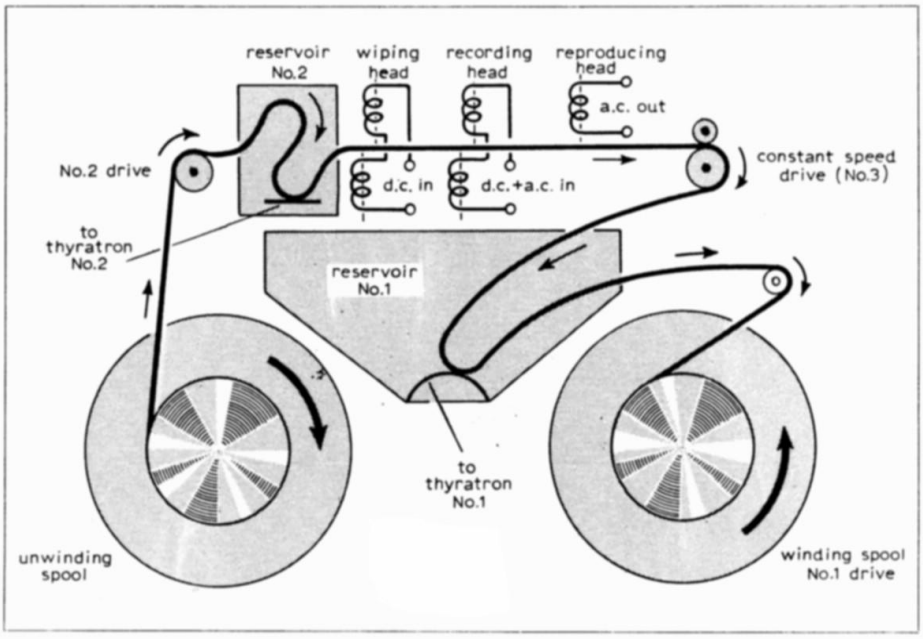

Fig. 5. Tape drive system for the Marconi-Stille machine.

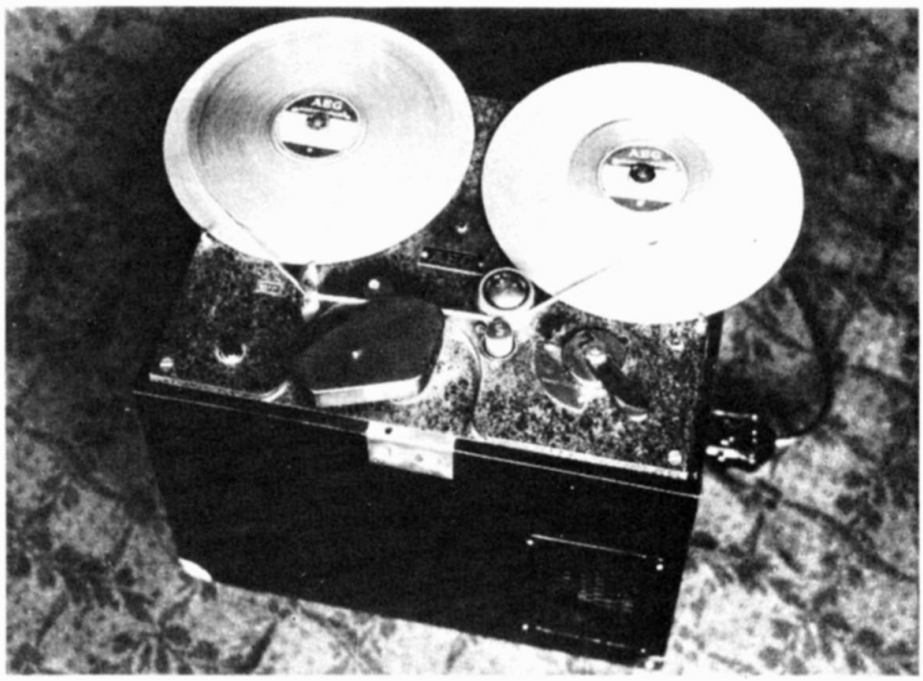

Fig. 6. The first model Magnetophone shown at the Berlin Radio Exhibition, August 1935.

dissolved sugar, molasses or the like, which is then dried and finally caramelized or carbonized, that is, the carbon chemically combined in the iron by heating. The steel powder so produced is then, while in a heated state quenched in water or other liquid, dried and again powdered. The use of such a material has for its object that phonograms are thereby obtained which last many years without loss of strength of sound."

He went on to suggest that this powder could be then mixed with a water-insoluble binder and coated onto paper or cellulose type films. Also in the patent he suggests the coating of sound stripes on moving picture film. Several alternative magnetic materials were included in the specification, such as nickel-iron alloys, ferrosilicon or iron-hydrogen compounds. At least one reference[33] indicates that Pfleumer did succeed in making paper tape, and also one coated on a cellulose hydrate film.

Fortunately for Pfleumer, A.E.G. were very interested in the proposition, but very soon realized that specialists would have to be used to manufacture a suitable tape. They chose I. G. Farbenindustrie Aktiengesellschaft of Ludwigshaven. This company specialized in the production of a wide variety of chemicals including fast opaque pigment dispersions and carbonyl iron used in the manufacture of loading (Pupin) coils for the telephone system.

Hermann Bücher of A.E.G. was soon in contact with a brilliant physical chemist at I. G. Farben, Wilhelm Gaus, who readily responded to the proposals and set to work on a suitable tape. The pace thus far seemed to have been a little slow from Pfleumer's first ideas, but now it increased—though not without quite a few problems, both technical and in company politics.

Some eighteen months after the initial approach Gaus reported back to Bücher that progress was good having received favourable reports on the quality of the first tapes delivered to A.E.G. In return, A.E.G. suggested that their machine was nearing completion and should be ready for launch in 1934 at the autumn Radio Exhibition in Berlin. With this air of optimism circulating, the two companies prepared for a grand launch. Designers at Ludwigshaven produced an exhibit which ran riot with ideas of the potential at domestic and broadcast level.

In July 1934, a decision to produce the first 10,000 metres of tape was taken, and by August this was in the hands of A.E.G. A further 40,000 metres was to be produced in time for the exhibition which was to be held from 17th to 27th August. With time getting short, internal politics started to show, since press releases and a prior announcement to a meeting of the Technisch-Literarische Gesellschaft du Berlin showed considerably greater restraint than the designers of the Ludwigshaven exhibit. Here an emphasis was laid on the speech recording aspect of the invention, rather than on music. Someone had suggested that any flaws in the performance would damage the prospects of the invention if exaggerated claims had been made initially. So, the plan was to underplay the potential, but as events were to show, this sudden pessimism was the precursor to real problems. A joint meeting of management from both companies, was held one week before the exhibition and demonstration given. The result was that the recorder was withdrawn, delivery of tapes stopped and the press information suppressed as far as possible.

The trouble was two-fold, first that the prototype machine made in breadboard form, suffered from amplifier instability when condensed into a practical cabinet. Second, the performance did not come up to that of the competition. Remember, the Marconi-Stille and its predecessors had been in practical service in broadcasting for at least two years and similarly, in Germany C. Lorenz had introduced the Stahlton-Band Maschine[34,35]. This was a steel tape machine using Stille's principles, but considerably smaller than the British versions having a frequency response up to 5kHz. The best achieved by the prototype A.E.G. machine was 3kHz at a tape speed of 1m/s. In addition the noise performance was hardly up to broadcast standards, so it was natural that there should be much soul-searching before taking any further commercial decisions.

Eight weeks later, the A.E.G. engineers announced that they had overcome the problems and a second demonstration was arranged. The resulting decision was favourable and so development went ahead to finally produce, in the summer of 1935, a completely redesigned model meeting all requirements and available for the 1935 Radio Show in Berlin.

With a potential success on their hands, I. G. Farben suddenly ran into internal political problems with two of their factories —Ludwigshaven, who had developed and produced the first tape, and Wolfen entrenched in film coating, squabbling over who should mass-produce the tape. Wolfen, by the way, was later to be split, by an Occupying Forces Commission, away from I. G. Farben to become the Agfa tape and film concern—but that is a separate story to be told later. The final decision was delayed until 1938, due to vacillation by the Reichs-Rundfunk-Gesellschraft, (German Radio) on which recording system to adopt. By 1938, Ludwigshaven was so firmly in full production that no decision needed to be taken.

However, this takes us beyond August 1935 and the Radio Exhibition where the first eight A.E.G. machines, now called the Magnetophone, were shown and demonstrated with success, indeed with so much success, they were all immediately sold. The first Magnetophone tape was cellulose acetate, coated with carbonyl iron powder. Since at the time, the steel tape, wire, and direct-cut disc were firmly entrenched in broadcasting it was to be some years of hard selling before A.E.G. was successful in getting the Magnetophone accepted by the German broadcasting stations and during that time several stages of evolution were to occur. The first model (Fig. 6) was to be superseded by the FT2 an elegant console model, and the K3, a portable machine in three parts—deck, amplifier and loudspeaker. These appeared in 1937[36] to be followed later by the K4, a broadcast machine made in portable or rack-mounted form. One interesting incident occurred in 1936 during the period of promotion; Sir Thomas Beecham was invited, with the London Philharmonic Orchestra, to go to Ludwigshaven to record the first public concert on magnetic tape. Beecham, being quite interested in recording, accepted and on November 19, 1936 made a tape recording parts of which survive to this day.

However, even he could not have been too impressed with the Magnetophone, since during that season he purchased two German optical sound recorders and had them installed in Covent Garden, where he later made private recordings of his seasons in 1937 and 1938!

Iron powder produced by the carbonyl process was not ideal as a magnetic material for tape since it had low coercivity and the individual particles were still too large to permit high-frequency recording. In addition the particles were spherical, a disadvantage not realized until much later when a study of small particle magnetics was to reveal the advantages of shape anisotropy.

However, there were other promising materials and one of these was magnetite (Fe_3O_4) suggested in 1934 by Erwin Leher. Some tape was eventually produced using this oxide, but it had rather too high a coercivity which made erasure a problem, and so brown gamma-ferric oxide, still with spherical particles, was eventually adopted.

It was in January 1938 that seal of success was to be set upon the Magnetophone when the technical manager of Reichs-Rundfunk Gesellschaft, Dr. Hans-Joachim von Braunmuhl gave an announcement at a lecture that the Magnetophone had been adopted by R.R.G. for broadcast service.

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