

THE FIRST X-RAY SOUND FILM (1935): ITS ORIGINS, IMPACT AND RESTORATION

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ABSTRACT

Cineradiography was developed in the 1920s as a medical diagnostic tool for examining movement inside the body. The earliest applications to speech produced only silent films with low frame rates. The recording of synchronised sound required improvement of the filming speed to 24 fps, a problem solved by Bonn radiologist Robert Janker, who cooperated with Paul Menzerath, then head of the phonetics laboratory at the University of Bonn, to produce a sound X-ray film first screened at the second ICPhS in London in 1935. The film created a sensation and established a paradigm for research in speech production for the next 30 years. Digital restoration of two surviving incomplete prints of the film preserved in London permits reconstruction of the original 1935 version, including the first ever X-ray slow-motion sequence of speech movements.

Keywords cineradiography, speech production, coarticulation, Robert Janker, Paul Menzerath

1. INTRODUCTION

Röntgen announced the discovery of X-rays in 1895 and the potential application to speech research was quickly pointed out [1]. Still images could be used to investigate the articulation of sustained sounds such as steady vowels but although a moving X-ray (of a joint in a frog's leg) was demonstrated by Macintyre as early as 1897 [2], the capturing of speech movements required filming from the dim and indistinct fluoroscope screen. By the late 1920s improvements in cameras, lenses, film emulsions, X-ray tubes and fluorescent screens permitted the making of short silent films within radiation dose limits then thought safe. In Bonn in 1930 the younger Hermann Gutzmann (1892–1972) presented a silent X-ray film of speech [3], but identified as shortcomings the low frame rate (16 fps), and the potentially harmful exposure levels. A sound film would be ideal, he said.¹

The 'ideal' was realised at the second ICPhS in London in 1935 when Paul Menzerath (1883–1954) presented the first X-ray sound film to an astonished audience.

As far as we can determine and reconstruct, what the audience saw was a film a little over 3 minutes in total duration. Of this, the first 1 minute 13 seconds is

occupied by lateral X-rays of a succession of speakers seen from the left side. They are seen and heard to speak successive sentences of a rather prosaic 50-word passage which explains what a sound X-ray achieves and points out that it is particularly applicable to the study of speech production but also to the recording of heart sounds and movements. The synchronously recorded sound is nicely demonstrated when one of the speakers stumbles over and has to repeat the word *Zungengrundes* within the phrase *des Zungenrückens, und Zungengrundes* ('of the back of the tongue and of the root of the tongue'). At approximately 01:13 a caption explains that without sound the filming rate can be raised to 48 fps. The remainder of the film is in slow motion, with further captions identifying the spoken material as various isolated vowels and consonants and the numbers one to ten. The film was shown in conjunction with Menzerath's paper to the Congress [4] (though the film is not itself the central focus of the paper) and additionally screened in demonstrations attached to the Congress and in a larger theatre nearby.

2. THE MAKERS OF THE FILM. MENZERATH AND JANKER

At the time of the film's production, Paul Menzerath was the head of the laboratory in the phonetics institute at the University of Bonn, considered one of the best-equipped laboratories world-wide. Born in Düren, Germany, in 1883, he was a psychologist by training but developed an interest in experimental phonetics and was put in charge of the phonetics laboratory at the University of Bonn when it was established in 1921. Menzerath gained wide notice for a ground-breaking monograph written with his Portuguese colleague Armando de Lacerda [5] which is still cited as the source of the concept 'coarticulation', and he also gives his name to Menzerath's Law, which states that the more elements in a chain, the shorter the individual elements are (for instance, the more syllables in a word, the shorter the individual syllables). It happened that one of Menzerath's colleagues at the medical school of the same university was a world-renowned specialist on cineradiography: Robert Janker (1894–1964).

Janker had to abandon a career as a surgeon in Munich after developing a wash eczema, and turned instead to radiology. He went to Bonn in 1928 and received his *Habilitation* from that university in 1930, the topic being X-ray cinematography, a field in which he continued to work, making prolific contributions and gaining an international reputation. Originally, he experimented with X-ray films of the lungs and the heart, adding speech to the range of subjects at a later stage.

3. IMPACT

Brief as it was, the film was widely seen as one of the highlights of ICPhS. In a report on the Congress for the journal *Language* [6], the American linguist Hans Kurath (1891–1992) wrote ‘In the field of experimental phonetics the outstanding contribution was the X-ray sound film by P. Menzerath ...Movements of the larynx, the soft palate, the tongue, the jaw and the lips are all visible in this remarkable film’.

In a similar review for the journal *English Studies* [7], the British linguist J. R. Firth (1890–1960) singled out ‘Professor Menzerath’s X-ray film’ as ‘of outstanding interest’.²

Perhaps the most enthusiastic account is that given by Louise Kaiser (1891–1973) in a report for the *Bulletin of the International Society of Experimental Phonetics* [8: 134]. She wrote ‘The impression is as overpowering as that of looking through a microscope for the first time. The world that is revealed is quite a new one. Speech is seen to consist physiologically of a continuous complexity of almost countless movements. There are no “speech positions”, no “on-glides” and “off-glides” or any of the other familiar clichés of non-experimental phonetics. The entire voice physiology of the present day is swept away at the first glance’.

She foresaw that cineradiography could provide a new paradigm for speech research: ‘The individual pictures—“stills”—afford opportunities for study and measurement that can furnish a basis for a new voice physiology that will meet the demands of modern science’. This was prescient to the extent that cineradiographic speech research was pursued in many centres around the world until around 1970.³ The fourth ICPhS in Helsinki in 1961 [9] saw five major contributions based on cineradiography, and the quantitative approach foreseen by Louise Kaiser reached a peak in the work of Joseph Perkell at MIT [10]. She was over-optimistic, however, in the hope that still frames from the 1935 film might be used this way. Although *movements* of the larynx, soft palate and tongue are clearly seen when the film is projected, the structures themselves are barely

discernible in individual frames. The resolution falls far short of what was achieved in still X-ray images of the day (see Figure 1).

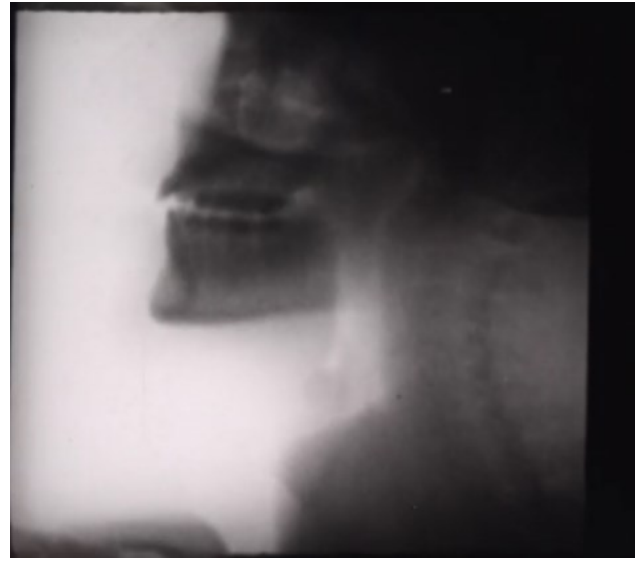


Figure 1: A typical single frame from the 1935 film, illustrating the relatively low resolution achieved.

4. MENZERATH’S VIEW OF THE FILM

Menzerath showed the film on at least two further occasions: at the 4th International Congress of Linguists in Copenhagen in 1936 [11] and at the XIe Congrès International de Psychologie in Paris in 1937 [12]. Neither in 1935 nor in these later publications did Menzerath attempt a systematic—let alone quantitative—analysis of the film. It seems that he was satisfied with using the film in a general way to support his views on coarticulation and did not make any effort to develop an experimental routine for applying cineradiography in phonetic research. His own estimation of the value of the film is certainly more reserved than that of Louise Kaiser. Remarks in [11] show that he realizes that the limitations in frame rate and the poor definition on individual frames can warrant only very guarded conclusions about the ‘continuity’ of speech movements, and that the relevant comparison is of average segment production rate with the achieved frame rate.

In all of these publications, Menzerath is named as the sole author. Menzerath concludes his 1935 paper with an acknowledgment to radiologist Robert Janker and [11] does make somewhat more explicit the cooperation with Janker, but the precise nature of their respective contributions is nowhere specified. Menzerath [4] refers to Janker as his *Mitarbeiter* (= someone working under his guidance), although all the technical innovations which made the film possible were certainly Janker’s.

It is hard to discern what Menzerath's contribution may have been. He held old-fashioned and prescriptive views on German pronunciation [13], and the speakers heard in the 1935 film (who sound like Bonn locals) can hardly have been selected by him. Similarly, the speech materials recorded show no obvious sign of being designed by a phonetician: the use in the slow-motion section of five vowels *a e i o u* in alphabetical order, the consonants *l m n r s t f w b p h* in unspecified contexts and the spoken numbers 1 to 10 rather suggests the opposite.

5. JANKER'S ACCOUNTS OF THE FILM

We have two documents authored by Robert Janker which shed light on the production of the film. The first [14] is a typeset document containing explanatory notes to the film C 150, *Röntgenfilm der Sprache*. C 150 was the number assigned by the *Reichsstelle für den Unterrichtsfilm* (RfdU), founded in 1934, which released and distributed the film in 1937, and the explanatory notes by Janker were originally published along with the film. The date of publication of this document has led to the film itself being dated to 1937, although we take C 150 to be the film as screened in 1935. It is uncertain whether the number C 150 was already assigned to the film in 1935.

The notes [14] explain that while cineradiography as such was not new, the combination of picture and sound presented a major problem. The method employed for the film was developed as a response to a contest which was advertised by the Zeitler foundation in Berlin in 1932 for the development of an X-ray film that would capture picture and sound of processes inside the body. Janker won the contest with a film using disks to record the sound. The 1935 film evidently represents the third generation of his steadily-improved sound-film attempts. The document includes the text which is heard spoken in the film, and an account of the 48 fps slow-motion section.

6. SOUND ON DISK

It is important to realize that by 1935 disks were used to *capture* the sound clips but they were dubbed to a conventional optical film soundtrack for projection. The advantage of using disks arose from the peculiar circumstances of working in the X-ray laboratory: radiation exposure limits meant each speaker appeared in a separate take lasting less than 10 seconds, and it would have been cumbersome and wasteful to attempt direct optical recording to film.

The fact that the individual takes are very short meant that synchronisation between the separately

recorded sound and picture within each short section would not be a major problem, provided only that in the editing process the picture and sound could be correctly aligned at the start. No doubt some sort of clapper-board system was used, but all evidence of the method used has been edited out of the resulting film. Assembling the edited film must have been a somewhat laborious process.

As indicated in [15], the direct-to-disk recording system used by Janker was one manufactured by the Dralowid Company in Berlin (which produced and marketed all manner of electrical and optical components). The blank disks, sold under the name Draloston, were coated with a resin which could be hardened and made durable after recording by baking in a special oven called the Draloston Duotherm.

7. THE MAKING OF THE FILM

A second document by Janker [15], dated 30 April 1963, is a typewritten transcript of the soundtrack for a 34-minute film *Entwicklung und Stand der Roentgenkinotechnik* (R 598) [16] made by Janker. That film presents a systematic and detailed history of the development of cineradiography, and of Janker's role in that development. It seems possible that Janker himself may be the speaker of the voice-over; certainly no other speaker is credited.



Figure 2: The recording setup used for the 1935 film. The light rectangular panel is the fluoroscope screen and the camera (not shown) is located to the right. Notice the large microphone mounted at the top right.

X-ray sound films of speech are dealt with at two places in the film R 598. Around 06:44 a photograph shows the 1930s filming setup (Figure 2) and at 08:25 begins a section just over 41 seconds in duration reproducing examples of the results.

Around 23:14 is an illustration of the more advanced and more comfortable recording setup used in the postwar period (Figure 3). By now Janker was using a 13 cm image intensifier manufactured by Philips. An example recorded in 1956 by a female subject begins at about 24:06 (Figure 4). The reduced radiation exposure resulting from use of the image intensifier permits the same speaker to remain in shot for the whole take of 1 minute 20 seconds.

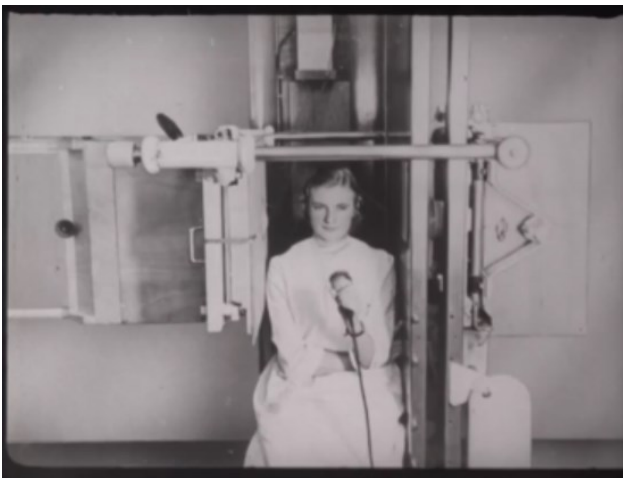


Figure 3: Recording setup of the postwar period, using a handheld microphone. The image intensifier and camera are to the right.

The script is only slightly modified from that used in 1935, and the film is again titled *Röntgenfilm der Sprache*. This has led to confusion in library and archive catalogues between films produced more than 20 years apart: a DVD of the later film [17] wrongly gives its production date as 1937.⁴ In fact, X-ray films from the postwar period are easily recognised at a glance by the circular image field resulting from the image intensifier (see Figure 4).

Janker also provided input to a 17-minute film called *Röntgenstrahlen* [18], directed by Martin Rikli and subsidized by the *Reichsstelle für den Unterrichtsfilm* which won the prize for best scientific film at the Biennale in Venice in 1937. A sequence on speech extends from 13:42 to 14:46 and includes material which does not form part of the 1935 film and is not known elsewhere, consisting of some multi-vowel words, the days of the week and the months from January through May.

8. RESTORATION

It is uncertain whether any complete copy of the 1935 film survives in Germany, and the search for one is made difficult by the unhelpful confusion which has arisen with the superficially-similar film of 1956.

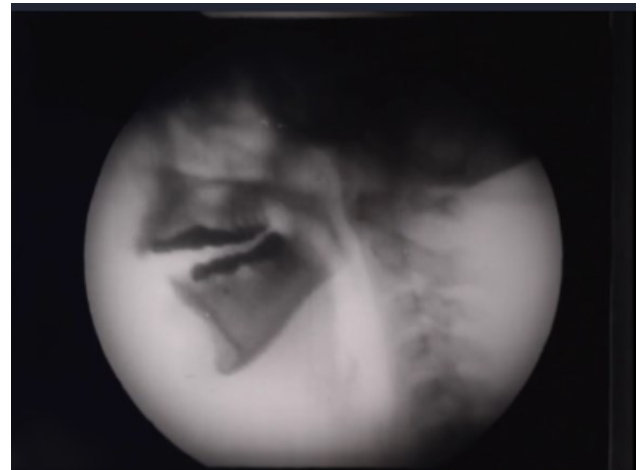


Figure 4: A typical single frame from the 1956 film.

Two 16 mm prints do however survive in London and came to light with other legacy film in 2008. One is a sound print of C 150, but is unfortunately severely damaged at the perforations along its entire length. It may have been left behind as a gift after the London congress, or obtained from RfdU soon afterwards. The other film surviving in London is a (double-perforation) silent print which is intact. There are reasons to think that it is a duplicate made locally from the sound copy before that was damaged.

The silent copy was digitised and screened by the first author in 2010. It runs for 3 minutes 20 seconds, and appears to contain the entire script as set out in [14] including the slow-motion (48 fps) section. It was possible to add synchronised sound to the first 40 seconds, taken from a fragment available online.⁵

But scanning and digitisation techniques have advanced over the last decade, and it is now possible to scan damaged film without access to the perforations. Our current restoration efforts are therefore directed at extracting as much information as possible from the damaged sound copy, and piecing-together from all the sources available a reconstruction of the film which contemporary judges found so ‘remarkable’, ‘outstanding’ and ‘overpowering’.

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¹ *Ideal wäre Tonröntgenfilm, für dessen Schaffung Verhandlungen angebahnt sind.* ‘A sound X-ray film would be ideal, for the production of which negotiations are in progress’. As far as we know Gutzmann’s film is not preserved. It was made in Berlin with radiologist Viktor Gottheiner (1899–1974). The rivalry between Janker and Gottheiner in the development of cineradiography will be covered in detail elsewhere.

² Firth had taught English pronunciation and intonation at a summer school at the University of Bonn in 1929 [19] and it seems probable that he was thus already acquainted with Menzerath.

³ Its impact upon phonetic research is perhaps comparable to the development of the sound spectrograph in the acoustic domain.

⁴ The confusion may have been made worse by the (presumably accidental) fact that the *Bestell-Nr.* (order number) of the DVD was D 150, resembling the C 150 number assigned to the earlier film.

⁵ <https://vlp.mpiwg-berlin.mpg.de/library/data/lit38421?> The fragment is identical with the relevant section of film R 958 [15] and stops short at the same point in the text. It may thus have been taken from the 1963 film rather than from an original 1935 film.