CHAPTER THREE

SOUND-ON-FILM: FRITTS TO DE FOREST

When Chladni showed his vibrating plates to the Emperor Napoleon, the latter cried out in surprise, "Marvellous! This Chladni lets us see sounds!"

ERNEST RÜHMEB, 1908

All in all, it is pretty well admitted today that any successful system of talking motion pictures must combine the sound record and pictures on a single film; any other plan only leads to trouble.

SCIENTIFIC AMERICAN, January 1923

The evolution of sound-on-film involved three different techniques: the groove-on-film, magnetic sound, and optical sound systems. The first never reached a satisfactory stage of technological development nor did it ever arouse any strong commercial interest, although in its most advanced form–as Madalatone–it was briefly but unsuccessfully marketed in 1927–28 in competition with various other systems. By contrast, optical sound was to challenge and eclipse sound-on-disk; then, in the late 1950s, after more than twenty years of universal use, it in turn was to be virtually eclipsed by the widespread use of magnetic sound systems.

GROOVE-ON-FILM

In effect, groove-on-film was nothing more than a variation of sound-on-disk with a track on the film performing the same function as the grooves on a record. The earliest such system was probably the invention of an American, John Ballance. It was covered by U. S. patent no.823,022, dated June 12, 1906. Balance's apparatus required the use of a stylus supported on a sound box at one edge of a phonograph horn. The stylus ran along a groove or track formed near the edge of the film and extending along its entire length. All later groove-on-film systems were merely variations and elaborations of this one.

Propjectophone, patented in 1916 by Katherina von Madaler, recorded sound by means of an electrically heated stylus connected to the diaphragm of a microphone. Sounds caused the diaphragm to vibrate and make the heated needle burn a wavy sound track in the film on which it was resting. The system was far from perfect; its major shortcoming was the same as that of most sound systems before De Forest's Phonofilm: inadequate means of amplification. Madalatone was a development of Propjectophone patented by Ferdinand von Madaler (presumably a relative of Katherina). It reached its final form in the late twenties, when it was described as follows by one of Ferdinand's contemporaries:

> Madaler . . . photographs the picture on the emulsion side of the film in the usual manner, but upon the unsensitized, or plain, side of the celluloid film strip, by the use of a diamond stylus, he engraves the voice in the form of a wave-line record similar to the recording of the voice upon a disk record. The film appears not unlike an ordinary motion picture positive film, but close examination with a powerful magnifying glass discloses a fine line, containing hills and valleys, so to speak, close to the perforation, and just outside the picture frame. . . . The film, including the emulsion, is but .005's of an inch in thickness. The engraved record line is only .002's deep. A speaker unit is employed, with an electrical circuit, to pick up the voice, or music record on the film, and this is again reproduced with suitable apparatus, employing cone speakers.[1]

In some versions of groove-on-film, two separate synchronized projectors were used, one for the projection of the film carrying the photographic images, the other for the film carrying the groove or track. Groove-on-film was never more than a curious byway in the history of sound cinema. No films of significance were made using any of the varieties of this system.

MAGNETIC SOUND

The basic principles of magnetic recording were first established by Danish inventor M. Valdemar Poulsen, a pioneer of wireless telegraphy. Poulsen found that

> if an iron disk similar to a phonograph disk be rotated and an electro-magnet arranged to travel over the disk in the same manner as the stylus travels over the ordinary phonograph disk, and if the traveling electro-magnet be energized with intensity varying with, and controlled by sound waves through a microphone of the usual type, a spiral magnetic path of varying intensity will be formed in the steel or iron disk. If the disk is then rotated and a solenoid [electromagnetic coil] be passed over the spiral path while connected with a suitable reproducing and amplifying mechanism, the sounds recorded magnetically on the iron disk will be reproduced in a manner similar to that of the ordinary disk phonograph. This method of recording and reproducing sounds had, of course, the advantage of eliminating the scratching effects of the needle or stylus on the record such as occurs in the ordinary type of phonograph.[2]

Poulsen named his system Telegraphone, and patented it in Germany and in the U. S. in 1900. It was first applied in a device for the magnetic recording of messages received by wireless telegraph, and then used for making a dictating machine (given the same name as Poulsen's system), which the American Telegraphone Company marketed in 1917 in unsuccessful competition with the already established cylinder dictating machines. It worked satisfactorily by the standards of the period, but was more complicated to use than the cylinder machines.

About the same time, Poulsen, working in collaboration with a fellow-Dane, P. O. Pedersen (director of the Polytechnic High School in Copenhagen), was applying his discovery of the principles of electromagnetic sound recording to the development of a method of making sound motion pictures. Instead of using an iron disk with a spiral track, Poulsen and Pedersen employed a magnetic ribbon 'or wire either running along the edge of the film that carried the visual images or on a strip of film separate from the images but synchronized with them.[*] Electric currents, controlled by a microphone arrangement, were used to magnetize the wire or ribbon while the movie was being shot. When the developed film or films were run through projectors with the requisite soundhead and loudspeaker system, the recorded sound was reproduced from the magnetized ribbon in synchronization with the projected images.

The two inventors gave their first public demonstration of the system in Copenhagen on October 12, 1923.[3] Demonstrations in other European cities and in the U. S. soon followed. However, the system was not a success.

At that period, in terms of clarity, tone, and amplification, magnetic sound-on-film compared unfavorably with the leading optical sound systems, particularly with Phonofilm. Poulsen and Pedersen were unable to get sufficient financial backing to perfect and promote magnetic sound-on-film. Magnetic sound would eventually triumph, but the story of that development is beyond the scope of this book.

OPTICAL SOUND

The origins of the recording of sound photographically may be traced to 1862, when the Viennese Czmark (or Czermak) took still photographs of the workings of the vocal cords. In 1876, the German scientist Sigmund Theodor Stein photographed the vibrations of violin strings and tuning forks, and two years later, Francis Alexander Blake of Brown University made a series of photographs showing the vibrations of a mirror connected to the diaphragm of a microphone. Blake used a clock mechanism to keep his photographic plates in motion. Like Czmark and Stein before him, Blake found no means of reproducing the sounds he had photographed.

An American, Charles E. Fritts, seems to have been the first to devise a method of recreating photographically recorded sounds, more than a decade before the inception of the motion picture! Fritts applied for a U. S. patent on October 22, 1880, though it was not actually granted until 1916, some time after his death. Earl Theisen, historian of photography and onetime curator of the Los Angeles Museum, described Fritts's patent as

> one of the broadest ever issued on any invention. It covers, basically, all the elements of sound recording as practised today. [The patent application describes] various systems of recording sounds by photographic means. . . . [It] specifies various slits, or shutters . . . which were coupled to a microphone diaphragm, as well as various optical systems in conjunction with mirrors for creating the sound record. These records were to be recorded on long photographic bands. Selenium bars were used in recreating the photographed sound record from a radiant energy into a pulsating electric current that vibrated a diaphragm to recreate the sounds. Selenium [was also utilized here perhaps for the first time in sound reproduction] as . . . an electrical resistor whose conductivity . . . [could be] increased with light intensity.[4]

During 1901–1902, the British physicist William Du Bois Duddell (designer of the Duddell oscillograph), taking advantage of developments in motion picture technology, conducted a series of experiments in sound recording by means of light, but was unable to improve significantly on Fritts's work.

Rather more success was achieved by the German inventor Ernst Walter Rühmer, whose Photographophone was used to record and reproduce sound-on-film—but without accompanying visual images. It was first demonstrated on December 12, 1901 at the Berlin Polytechnic. The invention is described in detail in chapter 4 of Rühmer's *Wireless Telephony in Theory and Practice* (1908). Rühmer used microphone sound currents (activated by the human voice) to produce variations in the intensity of a light ray issuing from an arc lamp. This ray was concentrated onto an undeveloped film that moved at a constant speed. The sounds originally transmitted through the microphone currents were photographically recorded when the film was developed and fixed. To reproduce these sounds, the inventor passed a beam of light through the photographically recorded film strip onto a light-sensitive selenium cell, whose currents operated a telephone. The recorded sounds could be heard through the telephone earpiece. Hence the system was sometimes referred to as "light telephony."[5] Unfortunately, serious limitations of the Photographophone prevented its being used to make talking pictures. Its carbon microphone was extremely insensitive; the casual fluctuations of its arc lamp produced unwanted noises; and its selenium cell generated sound currents that could be heard only faintly through the head telephone.

From 1901 to 1904 an entertainment known as the Singing Arc Light appeared in vaudeville shows in Europe and the U. S.[6] It may have been an offshoot of Rühmer's device, although the possibilities of the speaking arc had been known to scientists since 1897. The *Radiophone*, a booklet distributed at the Louisiana

Purchase Exposition in St. Louis, 1904, described a photophonic transmitter based on the speaking-arc principle; it had been patented on June 1, 1897 by one Hammond V. Hayes. H. Simon, a German scientist, also appears to have anticipated Rühmer's use of the arc lamp in a demonstration of light telephony that he gave to the Physical Society of Frankfort a/M on September 8, 1900.[7] But neither Hayes nor Simon used the arc lamp in connection with film. The precise nature of the Singing Arc Light entertainment has not been ascertained. One description simply indicates that it used a beam of light to carry human voices. Here, too, there is no evidence that film was involved.

The French inventor Eugene Augustin Lauste was evidently the first to make a motion picture with visual images and a photographically recorded sound track on the same strip of film. Lauste was a pioneer inventor of motion picture apparatus long before he became involved with sound recording. It is said that in 1867, at the tender age of ten, he conceived the idea of taking a paper strip from a Zoetrope (a moving picture toy based on persistence of vision) and oiling it to make it transparent—like a film before the invention of celluloid. Then he passed the strip through a magic lantern, covering up the lens between each projection of the pictures on the strip. Although the method was crude and not very effective, it was, undoubtedly, a primitive anticipation of cinematography.

Between 1887 and 1892 Lauste was mechanical assistant to W. K. L. Dickson at Edison's laboratory in Orange, New Jersey. He assisted Dickson in the research that eventually led to the invention of the Kinetoscope. In 1894–95 he joined forces with Major Woodville Latham in constructing and marketing the Eidoloscope, the first projector to use wide gauge film. It was first publicly demonstrated in New York in May 1895, a year before the commercial beginnings of American cinema. Lauste returned to France in 1896 and for several years thereafter was director of the American Biograph Company's laboratory near Paris.

According to Merritt Crawford, an authority on the inventor's life and work,[8] Lauste first conceived the possibility of recording sound photographically in 1888, while he was employed by the Edison organization. But it was 1904 before he was able to find the time and money to work on his idea. He was not slow in achieving results once he got started. On August 10, 1907 Lauste and two others (they were not coinventors but financial backers) were granted British patent no. 18,057 for a system called Photocinematophone. Crawford describes it as the "master patent in the field of synchronized sound and movement photography." The system was improved in 1910 by Lauste's invention of the string galvanometer, which enabled him to achieve sound recording by variable area exposure–a method that was to become basic to RCA Photophone, one of the two major sound-on-film systems to be adopted by many Hollywood studios in the late twenties and early thirties.

Crawford asserts that Lauste "first photographed sound and scene on the same film at his Brixton, London, studio" in 1910. However, another inventor, Elias E. Ries, applied, in 1913, for a U. S. patent on a single-film system. This patent was actually granted to Ries some ten years later and was to lead to considerable litigation over infringement of patent rights.[9] In 1911, Lauste visited the U. S. and demonstrated his Photocinematophone. He sought, unsuccessfully, to interest the film industry in his system, but the timing of his demonstration coincided with the presentations of the then more advanced disk systems of Gaumont (Chronophone) and Edison (Kinetophone). And he also made a short sound film (subject unknown), which Crawford claims was "the first true sound picture to be taken in America."

So far Lauste had been preoccupied with improving the quality of his sound recording and reproduction. But from 1912 on he increasingly turned his attention to the problem of amplification. Regrettably, he was never able to provide Photo-cinematophone with sufficient amplification for the system to be used satisfactorily in theaters. Nevertheless, between 1910 and 1914 he shot thousands of feet of sound films, none of which were commercially exhibited. Their subjects were of limited scope, as may be gauged from this brief account in the *Kinematograph Year Book* for 1915:

> M. Eugene Lauste, an elderly French experimenter and former assistant of Edison himself, has succeeded in constructing a wonderful apparatus whereby sound waves may be *photographed* upon a kinematograph film in such a way that the kinematograph record is capable of being made to reproduce the original sound again, not through contact of any needle

> or sapphire, but by the simple action of light acting through it upon an electrically energised resistance cell. When you have sat and heard the *Temptation Rag* played to you in rousing style through the means of an arc light, a kinematograph film, and a couple of telephone receivers you begin to realize something of what Shakespeare had in mind when he wrote: 'There are more things in Heaven and earth than are dreamed of in your philosophy' [*sic*].[10]

Crawford maintains that if Lauste's work had not been interrupted by lack of capital and the outbreak of World War I, and if he had been able to make use of electronic amplifiers, the sound era would have begun a decade earlier than it actually did.

Webb's Electrical Pictures, premiered at New York's Fulton Theatre on May 3, 1914, seem to have used a system essentially the same as Lauste's Phonocinematophone. The *New York Times* noted that "The sound of the voices in Mr. Webb's 'Electrical Pictures' is reproduced by a device whereby electrical vibrations are converted into natural tones. Both picture and voice are produced by the same apparatus and therefore the voice and action are synchronous." Webb's show presented a minstrel act and scenes from vaudeville and opera. Not much more is known about his short-lived enterprise, and it is not known whether Lauste ever came to hear about it.

In 1923, Photocinematophone in its most perfected form was demonstrated by Lauste to the editor of *Scientific American*, who published the following description of it:

> The motion pictures are made in the usual manner, either on standard film or on film of a larger width. The sound record is made alongside the motion picture 'frames.' The film moves intermittently—frame by frame—through the motion picture camera mechanism, and continuously before and after. While it is moving steadily the sound record is made. For this purpose the sounds to be registered are gathered by sensitive microphones, which modulate or vary an electric current accordingly. This modulated current is brought to the fine wires of a string galvanometer—a device consisting of fine wires placed in a powerful magnetic field, so that the slightest current flowing through the wires causes the latter to warp. A powerful beam of light is projected through the galvanometer strings and on to the sensitized motion picture film. Then, according to how much or how little the wires are warped by the current flowing through them, more or less shadow falls on the film which registers the results. Thus the finished sound record resembles the teeth of a saw, or the characteristic 'peaks' of a statistician's graph. For exhibition purposes the same film is passed through the projector and sound-reproducing device. The film goes through the projector mechanism intermittently, frame by frame, and steadily through the sound-reproducing device. A beam of light is passed through the sound record, and the varying degree of shadow, falling on a light-sensitive cell, causes a current of fluctuating strength to pass through a circuit which includes loud-speaking devices. Lauste has made use of selenium for his light-sensitive cell, which, as is well-known, varies its electrical conductivity according to the amount of light falling on its surface. However, this mineral is somewhat sluggish in its response to light variations, and that sluggishness is often sufficient to interfere with successful results.[11]

Lauste was never to profit financially from his achievement, but he has earned a permanent niche in film history as "the first to record sound and scene on the same film and to reproduce it. . . . The importance of his researches and early experiments," as Merritt Crawford has maintained, "will become increasingly apparent with the passing of the years."

Lauste is not exactly a household name even among film specialists. But for every hundred who know something about him and his work, it is doubtful if there is one who has even heard the name of Joseph Tykocinski-Tykociner, who gave a public exhibition of his optical sound system at the University of Illinois on June 9, 1922. In certain minor respects, however, Tykociner's accomplishment was more remarkable than Lauste's. His system cost less than $1,000 to construct (the university footed most of the bill), and he actually netted a profit of $100—his fee for writing an article on his invention and on the future of talking pictures.

Tykociner was born in Vloclawek, Poland, in 1867 or 1877[12] and first visited the U. S. as a student in 1896. Soon after his arrival he attempted, without success, to design an "improved phonograph" that would avoid sound loss from inertia or friction by using photographic film instead of wax cylinders. His idea for recording sound was to connect the diaphragm of a telephone receiver to a device that controlled a light source, and then to photograph the variations of light intensity. He proposed to reproduce the recorded sound by passing a ray of light through the film's sound track and converting it into a variable electric current. The sound would, he hoped, be received when the current was amplified through a telephone receiver system. Tykociner did not get very far with this invention, but in 1896, while it was still occupying his thoughts, he happened to see his first movie. A quarter of a century later he described the conjunction of the phonograph idea and the movie experience in an article he wrote for the *New York World.*

> I saw projected upon the screen athletic, military and simple dramatic scenes. . . . In a dark room marching soldiers were seen on the wall, performing movements under command of officers. No sound was heard other than the clicking noise of the projecting machine.
>
> I was impressed by the technical achievement, but the absence of sound made the show unnatural, and especially the mute dramatic scenes seemed to me unendurable. The necessity of sounds and especially speech in addition to the visual illusion was so manifest that I could not help associating the working of my new phonograph combined with the projection of moving pictures.[13]

Tykociner immediately set to work to realize what he had imagined. And by the end of the summer of 1896, he had already constructed two different kinds of sound recording camera.

> In the first he used sound to control the pressure of a gas jet in a lantern, and moved a photographic plate past the flickering flame. It is remarkable that this model worked at all. Most photographic negatives of the day were made on glass plates, and Tykociner had to develop intricate methods of dropping the plates past the slit. He was unaware that flexible film had recently become available. Nor was he able to get fluctuations in the flame that corresponded exactly to the very small fluctuations of sound waves. In his second model, the light passed through the opening of a vibrating shutter controlled by the diaphragm of a telephone receiver. This model was severely hampered because the shutters could not be moved rapidly enough. But Tykociner had discovered and purchased some flexible film which made it easier to photograph the light fluctuations.[14]

That was as far as he was to get for more than twenty years. What held him up was not a shortage of ideas but lack of money. He could not afford the selenium cell he needed for the apparatus to reproduce photographically recorded sounds.

Between 1901 and 1918 Tykociner worked in Europe. He undertook radio research for the Marconi Wireless Telegraph Company in England and the Telefunken Company in Germany. At the start of World War I he was employed by the czarist government to install radio links between the Russian fleets operating in the Baltic and Black seas. Then came the Revolution. Forced to flee from Russia, Tykociner decided to return to America. Back in the U. S., his thoughts returned to the old dream of recording and reproducing sound photographically. He obtained a position in the laboratories of Westing-house Electric in Pittsburgh, but resigned when he found that the company was not interested in supporting his researches into sound-on-film. At this juncture, Tykociner resolved to seek a university appointment, preferably in a school that would encourage his project. The opportunity arose in 1921 when he was invited to join the faculty of the University of Illinois as research professor of electrical engineering.

When Tykociner met Ellery Paine, his department chairman, he was asked which area of research he wished to investigate. Tykociner promptly replied:

> "I want to record sound on film."
>
> Paine was surprised. "You can't photograph sound."
>
> "Certainly not," Tykociner said. "But it is possible to photograph a light modulated by sound."
>
> Most of the Department's research was in power engineering, so Tykociner's idea was in an area unfamiliar to Paine. "Can you prove it will work?" he asked.
>
> The question annoyed Tykociner. "Prove it? That's why you do research."

> Paine was still cautious. "If you can show a committee of engineering faculty that your idea of photographing sound has merit, we will support your research."
>
> The demonstration, which was of urgent importance to Tykociner, took three weeks to prepare. After explaining his ideas about converting sound into variations of light on film . . . Tykociner pushed a button and a small bar of light appeared on a screen. As he spoke into a telephone transmitter the intensity of the light changed noticeably and bands formed across the slit, approximately corresponding to the sound of his voice.
>
> Tykociner explained that he needed to refine his equipment to produce a more accurate image of sound, photograph it, and find a way to convert the photographic record back to sound. Excited by the idea, the committee members offered the support which Tykociner had sought over two continents for 25 years.[15]

By a remarkable coincidence, the answer to Tykociner's major technical problem—the same one that had confounded him twenty years earlier—lay just across the hall from his laboratory in the Physics Building. Tykociner soon became acquainted with Jacob Kuntz, inventor of the photoelectric cell (1913), and almost immediately realized that he could reproduce sound by using a photoelectric cell instead of a selenium cell. It would, in fact, prove better for his purposes than selenium, which, as he probably knew, had never solved the amplification problem for Lauste.

What happened next was a triumph of improvisation.

> Tykociner borrowed vacuum tubes from the student-operated radio station and a motion picture projector from the College of Agriculture. The tubes had to be returned to the radio station each evening so that it could go on the air, and Agriculture would not allow Tykociner to remodel its projector. Film and electronic equipment were expensive, and the Department's research budget was small. He was forced to make a great deal of his own equipment and supervise the development of his film.

Tykociner's "microphone" was a carbon-grain telephone transmitter; his sound-reproducing apparatus included a Magna-vox speaker with a morning-glory horn; his camera was a Bell & Howell "Professional" model to which he had connected a penthouse sound recorder; and his projector was a Simplex. A modulated mercury vapor lamp was used in exposing the film, and the sound reproduction was, of course, dependent on the use of one of Professor Kuntz's photoelectric cells. But this heterogenous array of apparatus produced results that were at least as good as Lauste's and at times were considerably better.[16]

Tykociner completed his first talking picture in October 1921, within the same month that he initiated his experiments. It was a voice-only movie with the sound track running down the center of the film. The voice was Tykociner's, stating that this was "an experiment in the reproduction of sound," then counting from one to ten, and completing the test with a shout of "Hello!"[17] When Tykociner proceeded to make films with images, too, he shifted the sound track to the side of the film—but it was the opposite side from where it was to be located in most subsequent sound-on-film movies.

The public demonstration of the system, on June 9, 1922, took place in the auditorium of the Physics Building on the University of Illinois campus. Tykociner presented a "double feature." His first film showed a woman in a white dress (Mrs. Tykociner) holding a bell. Her lips could be seen to move as she spoke words that were clearly audible throughout the hall. "I will ring," she said. The sound of the bell could be heard next, as she shook it. Then, after a brief pause, she could be heard to ask, "Did you hear the bell ring?" The second film showed Ellery Paine delivering Lincoln's Gettysburg Address. Resounding applause followed the two brief films. Apparently everyone present was impressed. But many of Tykociner's colleagues subsequently voiced the opinion that what they had been shown was a toy, not a scientific achievement.[18]

At this stage, however, Tykociner was not to be depressed by such an attitude. His demonstration made headlines across the country, and he was asked to write an article for the *New York World*. Ironically, this was to earn him his only recompense for anything connected with sound pictures. Another article, by a reporter for the *World*, quoted Tykociner as saying,

> The voices in an opera, the music, the orchestra, the dialogue can be recorded and reproduced. Many noted plays, comedies and farces that are not adapted to the screen because of the wit and humor of the dialogue, the personality of the actors, may now be revived and find new favor. I have great hopes that it will cause a revival of the masterpieces of dramatic art.[19]

His hopes were to be short-lived. The Board of Trustees of the University of Illinois refused to promote any further research by Tykociner unless he agreed to assign to the university any and all patent rights to inventions he had accomplished with the institution's resources. Tykociner rejected the idea and headed for New York, where he expected to find a promoter in the film industry. But he was flatly turned down by every producer he approached as well as by executives of the General Electric Company. George Eastman delivered the *coup de grace* by telling the frustrated inventor, "I wouldn't give a dime for all the possibilities of that invention. The public will never accept it."[20] Tykociner headed back to Urbana, gave up any further thought of sound movies, and turned his attention to less sensational research in photoelectricity.

Perhaps Tykociner would have been less easily discouraged if he had known the real reason for General Electric's apparent lack of interest in his work. At the very moment when the company was rejecting his invention, a research team headed by Charles A. Hoxie and C. W. Hewlett was engaged in perfecting GE's own sound-on-film system at the company's laboratories in Schenectady. The Hoxie-Hewlett system was named Pallo-photophone (Greek for "shaking light sound"). It used a single film for the images and the sound track. A special feature of the recording process was the use of a mirror smaller than a pinhead. This minute mirror was made to vibrate by a fluctuating current from a radio microphone. It then threw a vibrating beam of light onto the edge of the unexposed film. The developed motion picture carried a photographic tracing of the sound vibrations in a zigzag pattern 1/10 inch wide along the entire length of the film. In reproducing the sound, the system employed a photoelectric cell, radio amplifiers, and a radio loudspeaker.

Curiously, Pallophotophone sound was first used publicly not for a movie presentation but for a radio broadcast. In the fall of 1922, the process was used to record the voice of announcer K. Hagar, which was then broadcast over GE's radio station WGY (Schenectady). The press gave widespread publicity to the experimental broadcast, viewing it as an important potential for radio. Typical reactions were these:[21]

> A few weeks ago a mysterious announcement buzzed off the aerial wires of our friend WGY at Schenectady. The announcement ran as follows:
>
> The next selection is for the benefit of the Edison convention at White Sulphur Springs, W. Va., to which WGY sends greetings. These greetings are being transmitted by a new device, not a phonograph, constructed by the General Electric Company, and by means of which the voice has been recorded and is now being reproduced. We would like to have comments from our listeners telling whether this last announcement came through as clearly as the other announcements on our evening program.'
>
> Mr. Hagar, studio manager of WGY, spoke those words a week before the radio audience heard them. No, his voice was not recorded on a phonographic disk; a new instrument, the Pallophotophone, was used. . . . Before describing the Pallophotophone it is interesting to know that WGY received many answers to their announcement, and every one of the fans who took the trouble to write was firm in the belief that Mr. Hagar's voice was more distinct than it had ever been before. Thus a new invention was introduced to the world over the radio. It was not only introduced, but it was given the acid test.
>
> [*Literary Digest*]

> Recently the Pallophotophone was employed to operate the radio broadcasting station WGY of the General Electric Company. The well-known voice of the WGY announcer, KH, was recorded on a photographic film and sent out over the radio phone with such accuracy that it was almost impossible to distinguish it from the living voice as ordinarily transmitted from that station. Indeed, it appears very likely that such applications of the photographic recording of sounds will become quite common in the future, and that lectures and important speeches may be simultaneously

> broadcast from several radio stations. This system has a definite application in recorded speeches, songs and other sounds for future generations. Its application to the theatre is, of course, obvious. [*Scientific American*]

Subsequent radio broadcasts using Pallophotophone included the recorded voices of President Calvin Coolidge and various other public figures.

Initially, General Electric's interest in sound-on-film was limited to its use in radio broadcasting, mainly because Hoxie and Hewlett at first spread their variable-area sound tracks across almost the entire width of the film, leaving no room for any photographic images. It was not until Hoxie demonstrated the effectiveness of Pallophotophone with a narrow variable-density sound track (it was only 1/16 inch wide) that the company decided to promote the system for use with motion pictures (c.1925). L. T. Robinson, chief of GE's General Engineering Laboratory, was appointed head of the research program for developing sound-on-film apparatus for commercial use. Improved loudspeakers were developed by Chester W. Rice and Edward W. Kellogg. And Professor A. C. Hardy provided a method for satisfactorily reducing the width of variable-area sound tracks so that they were an improvement over Hoxie's variable-density tracks.

Pallophotophone in its improved form was renamed Kine-graphone. As such it attracted the interest of Paramount, and in 1927 the studio took the option of using it to provide synchronized sound for William Wellmann's *Wings*, which premiered at the Criterion Theatre, New York, on April 12, 1927, less than two months before the momentous first night of *The Jazz Singer*.[22] The sound effects and music were actually added after the film had been shot. There were no recorded dialogue scenes. *Wings* was a spectacular, wide-screen (Magnascope) film about World War I aviators, starring Richard Arlen, Clara Bow, Charles "Buddy" Rogers, Gary Cooper, and Jobyna Ralston. Following its New York opening, the movie went on a series of road show tours. Simultaneously, the film was released in a silent version, but the road show presentations were all supplied with synchronized sound by Kinegraphone, for GE had leased to Paramount about a dozen separate sets of Kinegraphone apparatus for use with the road shows. Despite the commercial success of the experiment, Paramount did not use the system after the initial venture with *Wings*. Either the studio was unable to come to any long-term arrangements with General Electric, or else Paramount's executives considered the system less satisfactory than Movietone—which they contracted to use less than a year later. We shall hear more, subsequently, about these rival systems and their use by the Hollywood studios.

In 1921, a British inventor, H. Grindell-Matthews, was working, quite independently of Hoxie and Hewlett, on a sound-on-film process that was similar in several respects to Pallophotophone. A commentator for the London *Times* attended one of Grindell-Matthews's demonstrations and was impressed by the simplicity of his system which, he claimed, "involved only the addition of an adapter to ordinary projection apparatus."[23] Like Pallophotophone, the British system used only a single film for the images and the sound. In the process of recording, sound vibrations caused a "tiny mirror of stainless steel to vibrate two pencils of light, which in turn . . . [were] focused on the edge of the film. The film . . . [was] shown in the ordinary way, while from beneath the screen a 'sound shoot' . . . [amplified] the record[ing]." Although Grindell-Matthews's system may have been as effective as Pallophotophone—at least in the earlier stages of that system's development—it was never to be commercially exploited. The few sound films made by this inventor—entirely for demonstration purposes—included a farewell address by the explorer Sir Ernest Shackleton, who was filmed before leaving on one of his Antarctic expeditions.

Contemporaneously with Grindell-Matthews, a Swedish team headed by Sven Aison Berglund was working on a sound-on-filmsystem using two cameras and two projectors and employing a selenium cell in its recording unit. W. Bayard Hale was among those who attended a demonstration of the Berglund system (named Photophone but not connected with a later system developed by RCA) at the experimental laboratory of Brevik, ten miles from Stockholm. Hale's description of the experience was published in the London *Times* on September 24 1921. "What we saw," he wrote, "was Mr. Montelius [a Swedish professor] in his capacity as Royal Antiquarian and Director of the National Museum, at his lecture desk or moving freely about the platform without thought of a camera or a receiver, and what we heard were his words in a reproduction so perfect that it was almost impossible to believe that Montelius was sitting, with silent lips, at my side."[24] Notwithstanding its impressiveness at this presentation, Berglund's Photophone was to have no commercial future. In the early twenties it was already clear to those who had kept abreast of developments in the U. S. and Europe that if sound-on-film was to have any commercial prospects it would be through a single-film system that would use either a photocell or a magnetic recording method.

The most successful European development along these lines was the work of three Swiss-German inventors, Josef Engl, Joseph Massolle, and Hans Vogt. Beginning in 1918 and continuing into the early twenties, this trio collaborated on a sound-on-film system they called Tri-Ergon ("the work of three"), a single-film process. In a Berlin movie theater on September 17, 1922, Tri-Ergon's first audience saw and heard comedian Friedl Hintze recite Goethe's poem "Heideroslein."

Rights to the system were acquired about this time by the Swiss firm Ton-F. Zwecke, Glimmlampe für Licht-Tonaufnahme. Thereafter, through lack of promotional initiative and wavering interest in the possibilities of sound films, the rights were bounced from one organization to another. Ton-F. Zwecke sold them to the German UFA organization. In 1926, another Swiss company, Hauszer-Staub, Heberlein und Iklé, bought the European rights from UFA, and soon afterwards sold them yet again, to Tonbild Syndicat AG–usually abbreviated to Tobis. It was Tobis that commercially promoted the system in Europe, beginning in 1928–29.[25] The organization immediately became embroiled in litigation with RCA and Western Electric over alleged infringements of the Tri-Ergon patents. But the disputes were settled amicably in 1930.

Tri-Ergon used a photocell for sound reproduction. Its inventors discovered, as did Tykociner, that it was more effective than using selenium, which Lauste and others had found to be unreliable in response to fluctuations in illumination. The photocell was to be used contemporaneously in several other sound-on-film systems. But Tri-Ergon had another feature that was unique, a device for avoiding variations in speed as the film passed the photocell. It was a flywheel mechanism on a sprocket, a relatively simple device, but one that was to have devastating consequences for the American film industry. It was heavily protected by patents (most notably by U. S. patent no. 1,713,726). Between 1928 and 1934 every manufacturer of sound film equipment who did not work out a deal with Tri-Ergon's patent holders had the choice of infringing the flywheel patents (and facing the consequences) or marketing apparatus that was mechanically inferior to or more complicated than the Tri-Ergon equipment.

In 1925, William Fox, president of the Fox Film Corporation, acquired 90 percent of the Western Hemisphere rights to Tri-Ergon,[26] including, of course, the flywheel patents. In Hollywood, Fox's expenditure of $60,000 for a sound system must have seemed an absurd waste of money. But that was a year before the commercial beginnings of sound cinema by any Hollywood studio. By 1930, Fox was claiming innumerable infringements of his flywheel patent rights. On March 19, 1931 he brought matters to a head by filing suit against Electrical Research Products, Inc. (generally known as ERPI), Altoona Publix Theatres, and many other exhibitors. After due deliberation, a Delaware court declared that the Tri-Ergon patents were invalid on the grounds of "want of invention." On appeal, the case was heard by Judge Albert W. Johnson of the U. S. District Court in Scranton, Pennsylvania, who overturned the decision and upheld the validity of the patents. Fox now had the legal right to claim damages from countless producers and exhibitors across the U. S., Canada, and South America. Inevitably, the defendants appealed Judge Johnson's decision. But the U. S. Circuit Court sustained his verdict.

Now in addition to the defendants specified in the original suit, the two mammoth organizations, RCA and AT&T (through ERPI and Western Electric), were liable for vast sums for infringing the Tri-Ergon patents. Accordingly, they took the matter to the Supreme Court, where on October 8, 1934, by unanimous decision, the associate justices reaffirmed the verdict of the Circuit Court. They directed the U. S. District Court to appoint arbitrators to determine the specific fines to be levied against all the companies, organizations, producers, and exhibitors who had infringed Fox's patent rights.

The matter appeared to have been settled entirely to Fox's advantage, but his triumph was short-lived. An impressive array of senators and lawyers representing Wall Street business interests, theater owners, and

Hollywood studios appealed to the Supreme Court to reconsider its verdict. Incredibly, the Court agreed to reopen the case. Even more incredibly, on March 14, 1935, the same associate justices decided that "in the public interest" their previous decision should be overturned. The Tri-Ergon patents were, thereupon, declared invalid. No further appeal was possible. Now Fox, who had gambled heavily on collecting immense sums in damages, who had overextended himself financially, and who owed millions of dollars in legal fees, suddenly found that he was holding all the wrong cards. In 1930 his personal fortune had exceeded $100 million. In June 1936, he filed for bankruptcy, listing his total assets as $100. (Tykociner may have derived some wry amusement from that.) Meanwhile, Sidney Kent, the new president of the Fox Film Corporation, arranged for his company to merge with Twentieth Century Productions in order to secure the latter studio's Darryl F. Zanuck as his production chief. Thus, a fortune was lost and a studio born—on account of a flywheel patent.

Despite the overthrow of Tri-Ergon's American rights, the patents were still recognized in Germany. There, the major production companies, UFA and Klangfilm, obtained licenses to use Tri-Ergon in making their first sound movies.

Tonfilm, a rival optical sound system available in Germany during the twenties and thirties, was another development of the Danish inventors Poulsen and Pedersen. It used an oscillograph in the recording process and a selenium cell in the reproducing/amplifying process. Though less satisfactory than Tri-Ergon, Tonfilm was the system licensed by the Gaumont Company (in France) and was one of the systems licensed by British Acoustic, Ltd. (in England).

None of the pioneers whose work we have considered thus far contributed more to the perfection of sound-on-film than the American inventor Lee De Forest. Unfortunately, in his own lifetime, De Forest's achievements were almost forgotten in the wake of the tremendous commercial success of Vitaphone sound-on-disk and in consequence of the legal battles that consumed his time and money and deprived him of rights to some of his own patented inventions.

For most of our knowledge of De Forest we are indebted to the researches of film historian and archivist Maurice H. Zouary, whose invaluable collection of more than 100 of the inventor's pre-1928 synchronous optical sound films was recently acquired by the Library of Congress. Here we can only provide a brief outline of the work that Zouary surveys in various detailed articles, that Georgette Carneal discusses in her book *A Conqueror of Space* (the authorized biography of Lee De Forest), and that De Forest himself considered at length in his autobiography, *Father of Radio.*

As we have noted, other inventors before and contemporaneously with De Forest succeeded in making sound-on-film movies. But it was De Forest who found the solution to the problem of amplification. His key invention was the Audion Three-Electrode Amplifier Tube (U. S. patent no.841,386, dated January 15, 1907), which he originally conceived as a means of improving the reception of radio broadcasting. Through the Audion Tube, weak sounds received via radio (and also over telephone cable) could be greatly amplified. In 1912, when De Forest discovered that his amplifier could also be used as an oscillator, he realized that the invention could be applied to the making of sound movies. Hitherto he had been preoccupied with the development of radio, now he turned his attention wholly to the problems of talking pictures. In 1923, looking back on this period he observed:

> Perhaps the one consideration which, more than any other, prompted me to enter this field was my desire personally to develop a new and useful application of the audion amplifier—one which I could expect to develop largely by my own efforts as distinguished from its application to long-distance telephony, where obviously the intensive efforts of large corps of engineers, backed by a gigantic business organization, were indispensable. Another motive was my desire to see a phonographic device which would be free of many of the inherent shortcomings of the disk machine, notably the short length of record, the necessity for frequent changings of needles, and the belief that by means of a pencil of light, instead of a steel needle, it might be possible completely to escape from the surface scratch which has always been inseparable from the existing types of phonographs.
>
> Early in the spring of 1919 I filed patent applications on the methods which I believed would accomplish the above laid-down conditions, and began actual research on the various means which might be successfully employed. At that

time I figured that the work involved should require at most two years—a period one-half as long as that which has actually been demanded. The work has been almost uninterrupted, and of the most exacting and discouraging nature. Literally hundreds of experiments have been made and thousands of feet of film have been photographed only to be thrown away.[27]

De Forest experimented with magnetic wire recordings separate from the film carrying the visual images and also with two other methods involving a speaking flame (a method anticipated by Rühmer and others) and miniature incandescent filaments. At the outset the synchronization was imperfect, but he overcame that problem in due course; while almost from the beginning his Audion Tube provided more amplification than was possible with any other system at that period. The system he evolved used standard film with a variable density sound track (approximately 3/32 inch wide) running alongside the visual images.

In 1922 he outlined his process in general terms to one of his representatives:

Taking the picture:

1 Sound waves (voice of the actor) translated into electrical waves.

2 Electrical waves translated into light waves.

3 Light waves recorded on the edge of the film.

Reproducing the picture:

1 Light waves translated back into electrical waves.

2 Electrical waves translated back into sound waves.

3 Sound waves amplified with loud-speakers placed near the screen for the audience.[28]

In more detail, his recording system required three transformation processes: first, sound waves had to be changed into electric telephonic currents; second, these currents had to be amplified into light waves; and finally, the light waves had to be recorded photographically on film. To accomplish these processes, De Forest used a microphone transmitter that could pick up sounds up to fifteen feet from their source. The transmitter transformed them into weak telephonic currents, which were then amplified some 100,000 times so that they could activate a Photion tube in the motion picture camera. The Photion was an oxide-coated cathode located close to the objective lens. It generated light whose intensity fluctuated in exact rhythm with the strength of the telephonic currents reaching the tube. The light waves emitted by the Photion were directed through a narrow slit[*] onto the margin of the moving negative film, where they were registered photographically. Simultaneously, visual images were recorded on the same strip of film.

In order to reproduce synchronous sound and image, a positive print was made from the negative that carried both image and sound recordings. The print was then run through a standard projector to which had been added an attachment containing an incandescent lamp and a photoelectric cell. As the film moved through the projector, it passed between the lamp and the cell. Light from the lamp was focused through a narrow slit (like the one used in the camera), through the film's sound track, and onto the photoelectric cell, whose resistance was controlled by the intensity of the light falling on it. A small battery was connected to the photoelectric cell; its current, controlled by the intensity of the light activating the cell, was made to reproduce the currents originally transmitted during the recording process. But these currents were weak, and had to be strengthened greatly by the use of audion amplifiers. The now-powerful currents were sent through loudspeakers behind or beside the screen on which the motion picture was being projected. And in this complex manner audiences could see and hear a sound movie.[29]

Maurice Zouary quotes a speech by Dr. Elman Meyers, who assisted De Forest in 1913 with the first test of his single-film optical sound process. The test subject was a barking dog that turned a somersault. "Projecting the film with its sound on a De Forest invented projector sound device, marked this experiment as the first sound ever to be heard loud and clear, coming directly from a motion picture film."[30]

The inventor's first *talking* movie was made in 1921. De Forest noted in his diary for July 9 of that year:

> Today I made my first "talking movie" picture—of myself, very hot and somewhat flurried; talked too loud, and the photography was poor, due to white "back drop" and bad placing of the light. But it was *at last made*, despite all jinxes and hoodoos—two months behind schedule, and after two years of hard work in preparation—a definite promise of great things to come.[31]

De Forest was invited to Germany by the firm of Erich Huth G.m.b.H., and continued his experiments in Berlin. There he made his first sound movies for public presentation. His principal subject seems to have been his German assistant, Dr. Fritz Holborn, playing his violin—a rather curious parallel to the Edison Kinetophone film of 1894, in which that inventor's assistant, W. K. L. Dickson, had also played the violin. In September 1922 De Forest demonstrated, before an invited audience in a Berlin theater, what he had accomplished to date. German press reaction, he noted, was "polite, if not enthusiastically laudatory." He himself admitted that the "audio output was disappointing but adequate for the immediate purpose."[32] He had been forced to work with makeshift equipment and less-than-competent assistance, so he decided to pack up and return to the U. S.

Conditions at his Highbridge, New York, laboratory were as ideal as he could afford to make them. And back in the U. S. in the fall of 1923, he was also fortunate to receive encouragement and support from Dr. Hugo Riesenfeld, silent film composer and musical director of New York's Rialto and Rivoli theaters. When De Forest informed Riesenfeld that his experiments were advanced enough for him to proceed with the making of sound films for commercial exhibition, the composer offered to find him a studio, technicians, musicians, and the necessary equipment for film production, and to provide the Rivoli Theatre as a showcase for the De Forest movies as soon as they were ready.

The inventor decided to call his system Phonofilm, and in November 1922 he established the De Forest Phonofilm Corporation. A sister organization, founded at the same time, was the De Forest Patent Holding Company, which controlled all his patents in the field of sound recording and reproducing (more than 70 patents were involved). Production of Phonofilms began in the old Talmadge studio ("that ancient remodelled brewery of Tec-Art," De Forest called it) on East Forty-eighth Street in New York. The cameraman was Harry Owens, whom Riesenfeld sent over to assist De Forest. In the studio's heyday (1923–25) several short Phonofilms a week were being produced—a routine that anticipated Warner Bros.' regular production of Vitaphone shorts, beginning in 1926.

Interviewed by the *New York World* in May 1922 and the *New York American* in March 1923, De Forest offered some acute predictions about what his invention would mean to the development of the feature film:

> They'll have to direct pictures by the sign language. What will happen is that they will have to use real artists—actors who have a voice as well as a camera face. I think it will add brains to the movies.
>
> [Silent film] dramas are especially written for the screen and are designed to be without the human voice. But forward-looking screen writers will evolve something for the application of the Phonofilm to drama.[33]

At the East Forty-eighth Street studio at the beginning of March 1923, a reporter from the *New York American* was privileged to witness a demonstration of one of the films that De Forest would present publicly the following month.

> As I watched the movie of an orchestra performing, I heard the music it made. Piano, flute, clarinet, cello—I could distinguish the notes from the several instruments. The music played came from out of nowhere, from the direction of the screen. Measure by measure, it harmonized exactly with the movements of the shadow players.[34]

A preview of the public premiere of Phonofilm was held on April 12, 1923 before the New York Electrical Society in the auditorium of the Engineering Societies' Building. A packed audience saw short Phonofilms of Henry Cass describing the workings of the De Forest system, Eddie Cantor singing "The dumber they come the better I like 'em" and "Oh Gee Georgie," and Lillian Powell doing a bubble dance to the strains of a Brahms melody. De Forest noted in his autobiography, "Other numbers, exquisitely beautiful or rollicking comedy, followed in unbroken succession."[35] Phonofilm was launched publicly at the Rialto and Rivoli theaters three days after the preview. Its initial success led to the showing of Phonofilm programs in no fewer than thirty-four movie theaters on the East Coast between 1923 and 1925, as well as in Canada, South America, Britain, South Africa, Australia, and Japan.

Zouary estimated that De Forest made more than a thousand short optical sound movies by 1927. His Phonofilm system (at least *by name*) does not appear to have been used for a full-length talking feature film until the Weiss-Artclass production *Unmasked* (1929). The full range of Phonofilm short subjects is too vast to recount here. It included a variety of entertainment for all tastes: grand opera (scenes from *Lakmé*, *Rigoletto*, *Lucia di Lammermoor*); Pavlova and Fokina, each in a separate "swan dance"; various numbers played by the bands of Roger Wolfe Kahn, Ben Bernie, Paul Specht, xylophonist Teddy Brown, and Helen Lewis (with her All-Girl orchestra); Clyde Doerr and his Sax-o-phone Sextet; a short speech by Bernard Shaw (anticipating his sensational Movietone appearance of 1928); Chauncey Depew giving his personal recollections of Abraham Lincoln, and Edwin Markham reading "Lincoln, the Man of the People"; DeWolf Hopper reciting "Casey at the Bat," Monroe Silver in "Cohen on the Telephone," Elsa Lanchester in "Mr. Smith Wakes Up," Fannie Ward wisecracking about her age and singing "Father Time"; as well as performances by Eddie Cantor, George Jessel, Sir Harry Lauder, and Chic Sale; dialogues by Gloria Swanson and Thomas Meighan; Weber and Fields in their famous poolroom scene; sketches starring Raymond Hitchcock, Frank McHugh, and singer Harry Richman with a very young Joan Bennett; Una Merkel singing "Love's Old Sweet Song"; Max Fleischer's bouncing-ball song cartoons; the Jubilee Four (quartet of black male singers); many blackface minstrel acts and various "Mammy" singers, both Negro and blackface. Perhaps as early as 1923, De Forest also took Phonofilm outside the studio to make a short sound movie of New York City streets and people—a feat that would be considered a technological breakthrough when Sam Wood did it for the talkie feature *So this is College?* (1929). De forest was probably the first to shoot a sound picture outdoors—though that achievement has sometimes been attributed to the Fox Movietone engineers who filmed a parade of West Point cadets in 1927.

In 1973 the author was permitted to examine a number of the De Forest Phonofilms in the Zouary collection at the Library of Congress. A typical good example was a short sound movie of Norah Blaney at the piano, singing several of her songs, including "He's Funny That Way" and "How About Me?" The picture consisted of one 35mm reel (about 650 feet) with excellent synchronization but much surface noise. It was directed by Philip Braham, probably in 1922 or 1923. There were, interestingly enough for so short an experimental film, several camera setups and the use of fades as transitional devices. A poorer example was the outdoor Phonofilm of President Calvin Coolidge, taken on the White House lawn in the spring of 1924. Coolidge was seen against a background of trees, holding the notes of the speech that he delivered for the De Forest cameras: "The costs of government are all assessed on the people. . . . One of the greatest favors that can be bestowed on the American people is economy in government." This movie consisted of only 320 feet of 35mm film. The synchronization was found to be imperfect—the President's lip movements and gestures lagged behind his words—and the picture was static.

After the Phonofilm premiere in 1923, De Forest and Riesenfeld sat back and waited for the big offers to pour in from Hollywood. Could the studios be deaf to the miracle of sound? Could they possibly resist the opportunity offered by the dream De Forest had now realized? De Forest and Riesenfeld were in for a dismal awakening. Years later, the inventor reflected bitterly, "what stone walls of indifference, stupidity, and solid negativity did we unearth among the dead bones and concrete skulls of motion picture 'magnates'!"[36] Until the Vitaphone disk system (1926) suggested that there might be something in sound movies after all, not a single Hollywood executive showed serious interest in De Forest's enterprise. They generally wrote it off as a passing novelty that would bring financial ruin to anyone foolish enough to sink money into it. The reasons for Hollywood's indifference and even hostility to sound movies will be considered in more detail in the next chapter. Here it will suffice to mention that in 1923 movie mogul Carl Laemmle, one of the studio heads invited to a presentation of De Forest's sound movies, was too busy to attend. He sent an assistant, whose enthusiasm for what he saw and heard was promptly slapped down by other executives at Universal. Adolph Zukor *did* find time to sample a De Forest program, but he could still recall the failure of Edison's venture with the 1913 Kinetophone, and so he decided not to throw any of *his* money away on yet another crackpot invention without a future.[37]

Where Hollywood's reaction to Phonofilm was bland indifference, critical response vacillated between the apathy of Karl Kitchen, who headlined his review of the Rivoli premiere "New Talking Picture Is Shown—But What of It?",[38] and the excitement of Iris Barry, who described the film of Fokina performing her swan dance as "a most uncanny and delightful experience . . . it was just like seeing the ballerina herself."[39]

A technical objection was raised by De Forest's friend C. F. Elwell when he demonstrated a program of Phonofilms before the Royal Society of Arts in London, on November 26, 1924. After acclaiming the inventor's achievement of excellent amplification and perfect synchronization, Elwell went on to observe that there remained unsolved the further problem of "obtaining perfect mechanical reproduction of sound. The reproduction by the loud speaker, though extraordinarily good, does not yet render perfectly all the qualities of the human voice."[40]

Meanwhile, De Forest was temporarily less concerned about tone quality than about the promotion of the system to which he had already devoted so much time and money. He started a regular talking newsreel series in the spring of 1924—three years earlier than the famed Movietone. It was a presidential campaign year, and De Forest lost no opportunity of filming the candidates. Using "a pickup truck with battery-operated sound camera and amplifier," he journeyed to Washington to make the aforementioned Phonofilm of President Coolidge. The same day he filmed a speech by Progressive candidate Senator Robert La Follette, and then drove north to Long Island, where he recorded the opinions of Democratic candidate John W. Davis. Audiences in more than thirty East Coast theaters saw and heard these three preelection statements.[41] The following year, both Franklin D. Roosevelt and Al Smith made Phonofilm addresses prior to their campaigns for governor of New York.[42]

More ambitious than any of these short Phonofilms was De Forest's synchronized recording, in 1924, of a musical score by Riesenfeld, for James Cruze's epic Western, *The Covered Wagon*. In a 1941 article in *American Cinematographer*, De Forest claimed that it was with this film that he first introduced the method of "dubbed sound recorded in synchronism with a projected picture."[43] He notes in his autobiography that he first tried post-dubbing for a 1924 film of Sarova's dancers performing to the music of Grieg's "Song of Spring." He recalls that "They danced to the music of a single violin and cello, but the developed film was then projected on the studio screen while the full Rivoli orchestra replayed the music in perfect synchronization with the dancers'[44] The recorded score for *The Covered Wagon* presents the film historian with a possible controversy. Georgette Carneal, De Forest's biographer, states that the music was supplied for only two reels of the film during a special showing of *The Covered Wagon*.[45] But somewhat ambiguous comments by De Forest himself[46] lead one to believe that the Riesenfeld score was recorded for the entire movie, possibly anticipating by three years what Warner Bros. later claimed had been first undertaken with William Axt's score for *Don Juan* (1926). De Forest said that it was Riesenfeld's score that largely accounted for the Broadway triumph of Cruze's film.[47] But he may not have been referring to the synchronized recording of that score. There was a "live" orchestra at the Rivoli, and De Forest may have been speaking about their playing of the Riesenfeld music during regular showings of *The Covered Wagon*. Anyhow, in 1925, a year before *Don Juan*, Riesenfeld's score for Fritz Lang's *Siegfried* (1922) was recorded "in the Century Theatre while the orchestra was playing to the projected picture." Carneal says nothing about it, and De Forest nowhere intimates that the recording was for anything less than the whole film.

The years 1924–25 were remarkably prophetic as well as active ones for Phonofilm. *Domen* (1924), a short Phonofilm "talking picture play," was produced in Swedish by Arthur Donaldson; an English-language version, titled *Retribution*, was made early in 1925. De Forest proudly noted in his autobiography, "This was two years before Al Jolson's much-exploited *Jazz Singer*."[48] In spring of the same year, De Forest essayed a Technicolor sound film: "Balieff's entire Chauve Souris was . . . recorded, using a sound camera synchronized to the color camera. . . . The sound-track was then printed on the green positive, which dyed surface, although serving better than the red, was found quite unsuitable. Nevertheless, certain numbers of this production were exhibited . . . to enthusiastic audiences in the London Tivoli, and in Japan and Australia."[49] Zouary states that in 1925 De Forest made the first industrial sound film, which was shown at the Atlantic City Exposition.[50] But this claim is challenged by E. S. Gregg's reference[51] to the showing in 1924, at the Hotel Astor, of Western Electric's *Hawthorne*, a talking (disk-system) film about the Western Electric factory in the Chicago suburbs. It was in 1925 that De Forest unfortunately turned down the opportunity of buying U. S. rights to Tri-Ergon. Soon afterwards, William Fox acquired what De Forest had allowed to slip through his fingers, and within a year or so the movie tycoon was engaged in litigation with De Forest over the patent priorities of Tri-Ergon versus Phonofilm.

From 1926 to 1935 lawsuits were to consume much of the time and money that De Forest could have spent creatively and profitably in developing and promoting Phonofilm. The most unfortunate of these legal actions—regrettable because they brought into opposition two considerable inventive talents-arose out of De Forest's association with fellow inventor Theodore W. Case.

Case began his experiments in sound recording before World War I, while he was a graduate student at Yale. One of the earliest of his many patents was for the Thalifide cell, used by the army in 1917–18 in their infrared communications system, and by De Forest, in 1919, as a light-recording source in place of less-sensitive Kuntz photocells. In the early twenties Case visited De Forest's laboratory and got to know a great deal about the sound-on-film system he was working on. De Forest in turn visited Case's laboratory at Auburn, New York, and observed the gas-discharge amplifier tube devised by Case and his assistant, E. I. Sponable. "Forthwith," says De Forest, "I sketched out the first oxide-coated cathode glow-tube," which Case and Sponable then went ahead and constructed. It was the Aeo-light, which Case patented in 1927 (U. S. patent no.1,816,825), and which was to become fundamental to the Movietone system.[52] At one period De Forest employed the Aeo-light in his Phonofilm, but after 1925 he designed and used a new metal cathode recording tube and substituted improved photoelectric cells for the Case Thalifide cells he had been using since 1919.

Since his visits to De Forest's laboratory, Case had been working with Sponable on the development of a sound system that in most respects was identical with De Forest's. Georgette Carneal tells what happened next, according to De Forest:

> De Forest heard nothing further from Case other than that the latter was making talking pictures in Auburn and exhibiting them in Auburn theatres with equipment based on that which De Forest had loaned to these theatres long previously. Nevertheless De Forest made no move to stop Case, whose ideas had after all proved useful, until one year later, in 1926, De Forest learned that Case had set up his reproducing equipment in the Fox studios in New York. As a result of this demonstration Case had succeeded in interesting William Fox, who, not knowing De Forest's end of the patent situation, had immediately entered into contract with him and formed the Fox-Case Company to make pictures and exhibit them in the Fox Theatres under the title of 'Movietone.' De Forest observed with amazement that this name, Movietone, was, in his estimation, the chief distinction between the Case pictures and the De Forest Phonofilm pictures. He immediately brought suit against the Fox-Case Corporation for infringement of several of his patents.[53]

He also sued Tri-Ergon inventors Vogt, Massolle, and Engl (see further, Appendix E), the Stanley Company of America, and Western Electric (the two latter organizations on a charge of infringing his rights to the slit patent).[54] By 1935 all his patent claims had been upheld by the U. S. courts. He demanded and received less than $100,000 in compensation (he had spent more than $200,000 on Phonofilm and the compensation was eaten up by legal fees) and the legitimate right to call himself the inventor of sound-on-film. Unlike Fox, he had no desire to monopolize the American film industry.

The major Hollywood studios—not De Forest—were to profit by his invention. His Phonofilm Company—later renamed General Talking Pictures—never really gained a foothold in the movie capital. The organizations and companies De Forest had sued for patent infringements, and even those that brought suit against him, had what De Forest lacked: the resources to develop large-scale production of sound films while they were simultaneously engaged in litigation.

After 1926 hardly anyone outside a law court could be bothered with De Forest and Phonofilm. As we have seen, he could have brought Hollywood into the sound era in the early twenties. But the ears and eyes of the American film industry were to be caught at last not by sound-on-film but by the retrograde return of sound-on-disk, manifesting itself in a most spectacular swan song.

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* As we saw in the previous chapter, a two-film system of Poulsen and Pedersen was exploited by the Gaumont Company. GPP, as the system was called, used optical sound-on-film-not the magnetic principle.

* The slit idea originated with Elias E. Ries and was patented by him in 1924. However, De Forest seems to have come across it independently, as early as 1920. In 1924, when he discovered the existence of the patent, he bought the rights to it from Ries. The slit idea was, of course, basic to the De Forest system. See further Georgette Carneal, pp. 288-289.