How De Forest Makes the Movies Speak

By Alfred M. Caddell

This is an interesting account of the application of radio principles to the recording and reproducing of sound for use with moving pictures. It represents the results of Dr. Lee de Forest's work for the past three years.

THE simultaneous record of sound and motion on a film is a problem that has engaged the attention of inventors for many years. Of the several methods that have been devised, that of Dr. Lee de Forest is of especial interest to radio amateurs, not only because of his pioneer work with the vacuum tube, but also because of his application of some radio principles to the solution.

The chief difficulty to be surmounted was to reconcile picture or light photography at a speed of 186,000 *miles* a second and sound photography at 1090 *feet* a second. This was finally done by superimposing the slow vibrations of sound first on electrical waves and then on light waves, thus giving synchronization so that the sound from the actor's lips is photographed simultaneously with their movement.

In ordinary conversation, the vibration frequency of a man's voice is between 700 and 800 times per second; that of a woman's between 1000 and 1200, and that of many musical instruments higher still—the piano ranging from 27.2 for the lowest note to 4138.4 for the highest. And those comparatively slow vibration frequencies have to be superimposed on a train of electrical (radio) vibrations.

Almost every radio fan knows the method by which the voice vibrations may be made to modulate an electric current. You speak into a microphone or telephone transmitter, the vibrations produced by your vocal cords setting up a variable output of sound waves. These variations cause changes in the microphone resistance, which in turn causes an electric current to vary in intensity. In radio this current is stepped-up and applied to the grid circuit of a modulating or vacuum tube, which amplifies and transforms it into electrical waves to be radiated from the antenna.

Up to a certain point the same proceedure is followed in photographing sound. As the players of the movies are being photographed in their parts—acting, speaking, singing—the resulting sound waves fall upon a "converter," which is similar to the microphone of a telephone transmitter, only very much more sensitive. The sound waves strike against a parchment disk which vibrates at the faintest sound. At each fluctuation of sound this disk varies the flow of an electric current exactly as the microphone does in a telephone circuit. This telephonic current is then applied to the grid of an audion tube which impresses the plate current of the tube circuit, so that the output is a greatly strengthened voice-impressed current.

But here is where paths diverge—instead of being impressed on a high-frequency oscillating current to be radiated from an antenna, as in radio, this voice-controlled plate current passes to a high-frequency generator, whence it is led to and made to vary the intensity of a special kind of electric light, *the photion*, which is fitted into the standard motion picture camera. This varying light, allowed to stream through a narrow slit (only 1/40th of a millimeter wide and 1 millimeter long) makes its impression the same as a photograph on a section of the moving roll of film at the back of the camera. And the film, after being

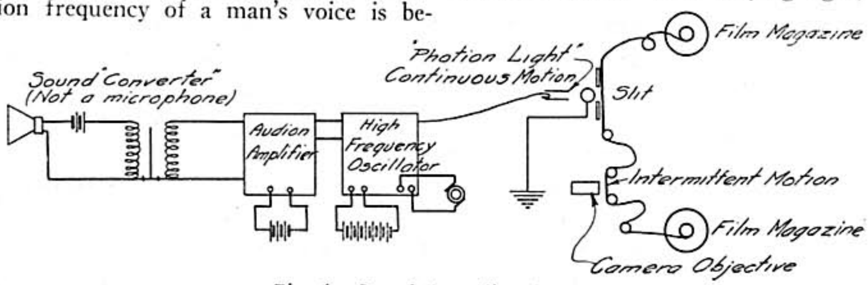
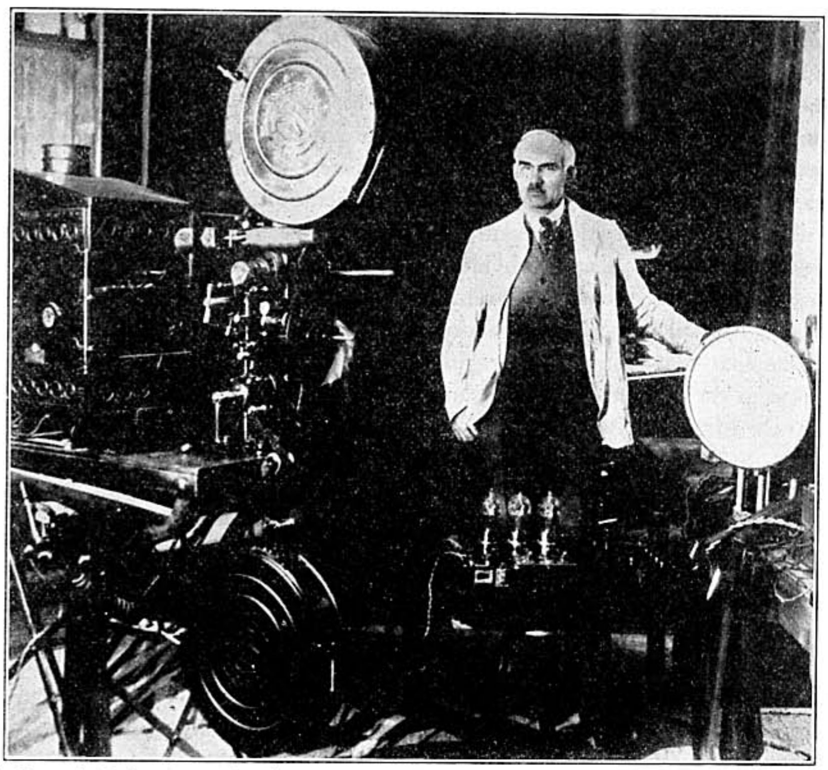


Fig. 1. Sound Recording System

Enlarged "Positive" of Phonofilm, Showing Sound Record Between Picture and Perforation at Left.



Dr. de Forest's Laboratory, Showing Projection Machine Used to Reproduce the Sound on the Phonofilm. The Weak Voice Currents Registered from the Film Are Magnified by the Vacuum Tubes in the Foreground

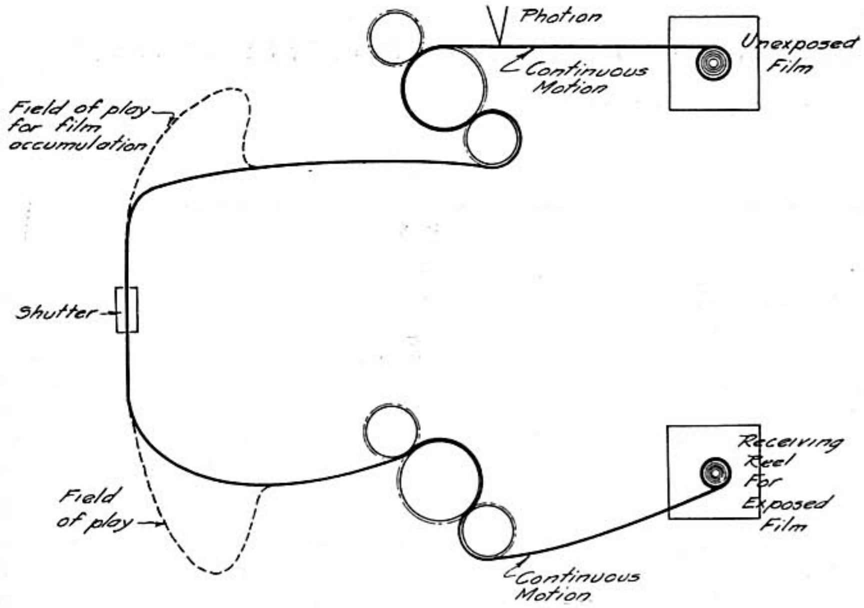


Fig. 2. Sound Projection System.

Dr. de Forest and Recording Camera. He Holds "Photion" in Right Hand and Microphone in Left. The "Photion" is Placed in the Small Opening, Above the Lens. The Microphone Converters are Placed in Receptacles All Around the Field of Action to "Pick Up" the Sound.

developed by the usual photographic process, shows not only the picture but what looks like a narrow path of uneven hairline marks, or rills, which are the *varying intensities* of the photion light as they streamed through the microscopic-size slit and registered on the rapidly moving film.

About the Photion.

An ordinary electric light filament has too much of a "lag," being incapable of delicate control by varying electric currents. The ordinary 60-cycle current goes on and off 120 times a second, which gives a sense of continuity to eye. But it could not be made to vary 800 times or more a second, to accommodate the different vibrational sounds of a man's voice (and higher for musical instruments, etc.). So a gaseous "filament" became necessary, something that would act quickly and correspond exactly to the vibrations of speech and music. The photion registers high-pitched musical notes on the film at the rate of about 3000 per second; which means that each of the vibrations of the parchment disk of the "converter" is transferred to the electric current and that the light *brightens and wanes 3000 times* in one second, which light variations are instantly recorded alongside the picture on the film.

Thus the photion is a glow lamp containing a mixture of gases which are made luminous by the passage of a high-frequency electric current. The flickers or changes in intensity of the violet glow correspond to speech modulations which have been superimposed on the high-frequency current by means of the sound converter and amplifier tubes. The flickering is photographed through a slit onto the film so as to make dark lines when the photion is bright and gray lines when dim.

To reproduce this series of lines as sound a strong light is shown through the film so as to fall on a sensitive photo-electric cell whose metal plate gives off electrons when illuminated, the number of electrons given off depending upon the intensity of the light. The more light the more electrons, the variation in electron flow corresponding to the variations in light intensity and thus to the original voice modulation. This flow of electrons constitute a feeble electric current which is amplified by four or five vacuum tubes until it has sufficient strength to operate a telephone loud speaker and thus reproduce the sound.

The photo-electric cell, like the photion, has been the subject of considerable research by Dr. de Forest, who has finally developed an exceedingly sensitive device. It consists of a metallic coating in an evacuated glass bulb. This coating may be any one of a number of substances, including selenium, potassium, rubidium, molybdenite or silver nitrate.

The entire process is shown in the accompanying diagrams. Fig. 1 shows the recording system, Fig. 2 the projection equipment and Fig. 3 the means for synchronizing sound and motion photography.

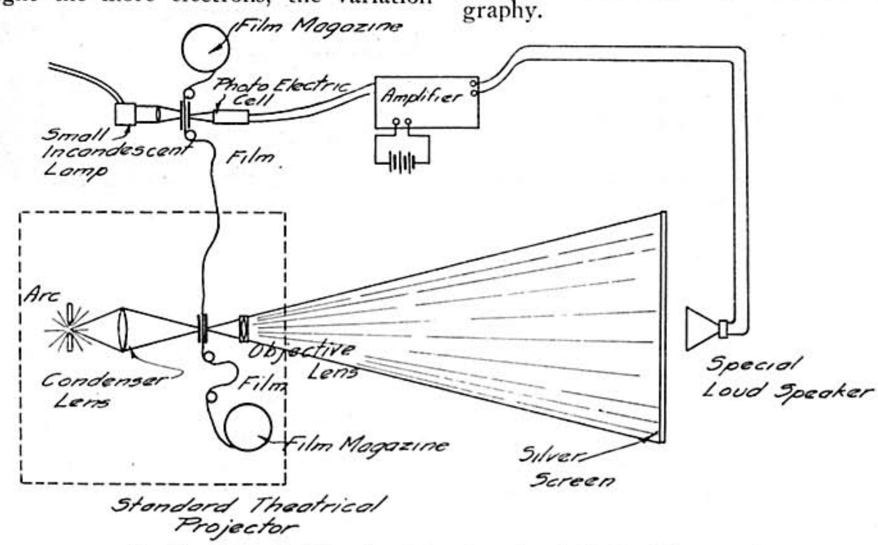


Fig. 3. Method of Synchronizing Sound and Motion Photography

Summarizing, we record pictures and sound: (1) by superimposing sound waves on electrical waves; (2) by superimposing electrical waves on light waves, and (3) by photographing the light waves on the edge of the film, alongside the picture of the actor who spoke or rendered the music.

To reproduce pictures and sound the process is reversed: (1) As the film likeness of the actor is being run off, the photographed light impressions on the edge of the film are transformed into electrical waves, which are in turn (2) amplified by vacuum tubes and (3) transformed into sound waves by the well-known electromagnetic action of telephone receivers, or as in this case, loud speakers placed near the screen so that everyone in the audience may hear.