in the motion of the disc turntable or the film-drive sound-sprocket. A separate filter is used for each purpose; but both are built upon the same principle. No matter how much care has been exercised in the design and manufacture of the machinery, there is a certain amount of fluttering or irregular motion, due to the meshing of the gears, etc. The mechanical filter is designed to overcome this and deliver an absolutely even flow of motion, taking up all the shocks, fluttering and irregularities. Fig. B is a picture of a Western Electric mechanical filter for the disc. At one side is the housing, containing the driving shaft which connects the motor with the worm gear, part of which is shown engaging the circular gear. On the latter are mounted six springs at three different points. The other ends of these springs are connected to the turntable drive shaft by means of the triangular part mounted in the center of these springs. The turntable is mounted directly on this shaft and the only connection to the driving unit is through these springs. The difference between this filter and the film-sprocket filter is that the triangular part is connected, not to the turntable shaft, but to a heavy flywheel firmly fixed to the driving-film sound-sprocket.

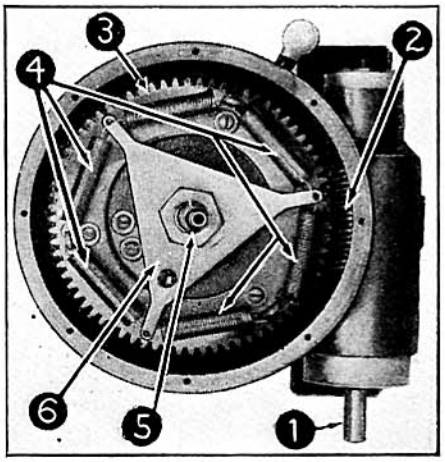

Fig. B

Disc-type mechanical filter: 1, motor drive shaft; 2, worm gear; 3, ring gear; 4, springs; 5, turntable drive shaft; 6, triangular connecting link.

In Figure C is shown the Western Electric universal base, upon which is mounted everything necessary for one machine to project sound pictures. This machine, when assembled, may be moved as one complete unit; thus doing away with the alignment of various parts, so common with many installations and with the earlier models of Western Electric sound apparatus.

The positions of the mechanical filters for film and disc is easily discerned; turntable, reproducer unit and arm, and mechanical filter are mounted in a suspension arrangement of rubber which absorbs any mechanical vibration of the machine. The shaft which connects the motor to the mechanical filter is in two sections coupled by a rubber hose as an additional buffer.

The Methods of Sound Picture Recording

By JOSEPH RILEY

THE electrical recording of sound requires a method of transforming sound vibrations into electric currents; then the transmission, control and amplification of these currents, and finally, a method of changing the electrical energy into mechanical energy, so that a permanent record may be impressed on the recording medium—either by modulated light on a sensitized film, or by the movement of a cutting stylus in soft wax.

In a recording studio, the essential apparatus consists of the microphone pick-ups on the stage, a mixer and volume control, amplifiers, recording machines, and a synchronous motor system for synchronizing the recorders with the cameras.

The stage on which recording is done is constructed purposely to exclude external noises by covering the walls and ceiling with sound-absorbing materials.

As in the broadcast studio, particular care must be taken in placing the microphones, to record successfully the speech or music occurring on the set. However, it often happens that the problem of locating the microphones is complicated by the construction of the set, and by the necessity of keeping them out of view of the camera. In such a case the "mike" then may be hung from the ceiling (as in Fig. B) or suspended from the end of a long boom (as in Fig. A). The microphones used are generally of the condenser transmitting type; this is, briefly, a condenser in which one of the plates is a very thin, stretched sheet of duralumin, which may be set in motion by the vibration of the sound waves. The capacity of the microphone is thus varied, and a modulation is caused in the electrical circuit to which the microphone is connected.

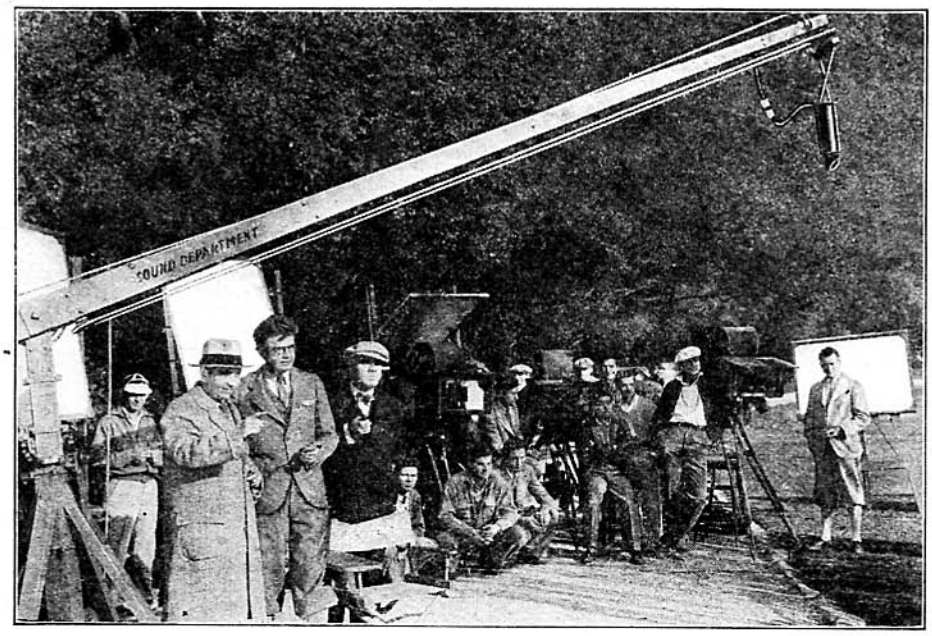

Fig. A

A sound-picture staff on the lot; the microphone hangs below the amplifier at the end of the boom. The cameras used are larger and more complicated than the hand-operated type used for silent pictures.

Courtesy United Artists.

Camera booths are constructed of sound-proof materials to eliminate camera and motor noises, but have a clear glass window in front for the camera to "shoot" through. In Fig. B a sound-proof camera booth is shown in an actual studio scene.

The Man Who Hears

The person responsible for the balance, quality and volume of the recording is called the "monitor man." His duty, is first, to place the microphones properly after determining the acoustic conditions of the set; and he must be, therefore, very familiar with the action being photographed. He then sits in a bay window in the "monitor room" with a clear view of the stage and, by means of special horns only, since his room is insulated from the stage by sound-proof walls, hears all sounds picked up from the stage.

The centralized control for the whole system is the "mixer table." Here controls are located for fading microphones in and out, maintaining volume balance between several microphones, and regulating total volume; also for operating communicating systems, signal lights and relay-control switches. The monitor man in his room has a visual volume indicator, to help him keep the sound

volume range within the limits of the recording system. The amplifier room contains the system amplifiers, monitor amplifiers and power-control panels.

If the picture is to be released with the sound recorded on film, the common practise is to operate two film recording machines for the permanent film record, and one wax recorder for "playback" purposes. The use of the wax playback has proved advantageous to the director and actors for immediate judging of the dramatic effort and the quality of the recorded scene, without the necessity of waiting for the film or wax record to be completed. The recording rooms usually contain two film and two disk recording machines, which are all driven in synchronism with the camera motors on the set.

Fig. C

A "frame" of sound motion-picture film, enlarged. The sound track at the left, between the sprocket holes and the picture, represents the sound frequencies recorded in synchronism with the action, though not necessarily on the identical piece of film, because of the distance separating the optical camera from the sound recording device. This may be compared with the film on page 457 of the March issue of RADIO-CRAFT. *Both record sound fluctuation by light and dark areas, but in different types of patterns.*

Courtesy R. C. A. Photophone, Inc.

Record on Film

Perfect synchronism between the action and the accompanying sound is inherent, since the picture and sound record are made in fixed relation on the same piece of film. Standard film is used, but a small portion of the width of the film one-tenth of an inch wide is used for the sound track (Fig. C, and see also page 457 of RADIO-CRAFT for March.) The sound vibrations are recorded in this track as alternate light and dark lines of varying density. In the projector, these lines serve as a means for the reproduction of the original sound, accurately synchronized with the action.

The vibrations of the air which constitute sound are picked up by the diaphragm of the microphone. The vibrations of this diaphragm in turn give rise to feeble electrical oscillations, corresponding in frequency and strength to the pitch and intensity of the original sound. These weak oscillations are then amplified enormously by four or five stages of vacuum-tube amplification. The amplifier must have very faithful characteristics; so that the output shall be an undistorted copy of the input, except that it is much greater in volume. This pick-up amplification is similar to that of the speech input system of a broadcast station, or of a public-address system.

The output of the amplifier is applied to a special vacuum glow tube called an "Aeo" light. This tube glows with bluish-white light of its normal brightness when a uniform direct current of ten milliamperes is passed through it. When the sound-modulated output from the amplifier is also applied to the tube, the glow is alternately increased and partially extinguished; it follows the modulating current in frequency, for it varies in intensity with that of the current. The action of this tube is somewhat similar to that of the neon lamp used in television work. The light from the "Aeo" lamp then shines through a slit and optical system (as in Fig. 1) which brings it to focus on the film, as a fine line running crosswise of the sound track. According to the modulation applied to the "Aeo" light, there is produced in the developed film a series of alternate light and dark lines whose spacing and contrast depend on the frequency and intensity of the modulated current applied to the "Aeo" light. A low note corresponds to a slow frequency of sound vibration, and results in a wider spacing of lines on the film. A high note, corresponding to rapid frequency of sound vibrations, results in a close spacing of the lines. Relatively pure notes, such as those from a whistle, give uniform alternate light and dark lines; while the complex sounds of speech and orchestra are recorded in quite complicated patterns.

A camera similar to those for making silent pictures is used in the sound-on-film method. However certain modifications are made to adapt it to recording sound and picture simultaneously. It is provided with a holder for the slit and "Aeo" light, at a point where the film moves uniformly, and with a motor drive (Fig. 2); since it is not possible to crank smoothly enough for sound recording, especially at the speed of ninety feet of film per minute. On the other hand, the camera must be quiet, so that noise from its operation shall not be picked up in the microphones and recorded along with the desired sound.

Sound on Wax

If the picture is to be released with the sound recorded on discs, the electrical impulses, after coming from the amplifiers, are fed into the recording mechanism. The wax recording machine used in the Western Electric system consists essentially of the following parts: a motor drive; a reduction gear, with a belt drive connected to the lead screw which moves a recorder radially across the surface of the wax disk; and a second reduction gear driving a turntable on which the wax is placed.

Recording is done with an electrical recorder receiving its power from the system amplifiers. The electrical energy drives a cutting stylus, made of sapphire or ruby, which must be sharp to insure a clean cut; since any roughness in the walls of the groove introduces extraneous noises into the reproduced sound. In "lateral" recording, which the Western Electric system uses, the vibrations are produced along a radius of the disc record; so that the stylus cuts a spiral groove of constant depth, about 0.0025-inch, but of varying width.

The lateral method of recording is used

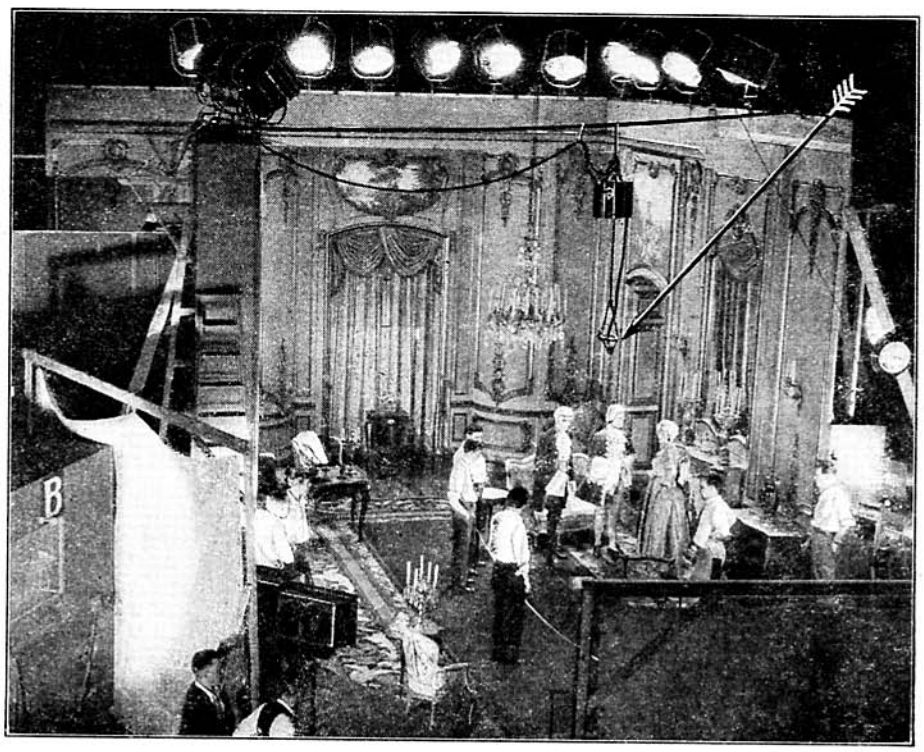

Fig. B

Recording a talking picture at R. C. A. Photophone's Gramercy studio, New York City. The arrow points to the microphone. The optical camera is behind the screen at the lower right; the white line on the floor marks the area of the picture. The sound is recorded in the sound-proof box at the lower left.

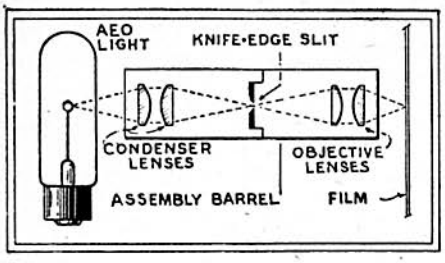

Fig. 1

The system of recording sound on film may be compared with that for reproducing it from the film, shown on page 517. The AEO light flickers according to the audio modulation of its current.

almost exclusively in sound picture work. The original wax is a disc of metallic soap, from thirteen to seventeen inches in diameter and about one inch in thickness. This disc is first given a high polish, before being mounted horizontally on a turntable which is driven at a uniform speed of approximately thirty revolutions per minute (or less than one-half the speed of the ordinary phonograph). At the same time, the disc is being synchronized with the film being run through the cameras. On the ordinary phonograph, the reproducer travels in playing from the outer edge towards the center of the record; but, in sound recording, the stylus is made to travel outward from the center of the disk at such a rate that it cuts a spiral having the pitch of about one hundred turns per inch.

As mentioned before, as soon as the wax has been cut, it is desirable to play it at once, in order to detect any flaws by the play-back. This special reproducer is extremely light, so that it produces no appreciable wear on the comparatively soft wax record. Then if the wax is pronounced satisfactory, it is dusted with a fine conducting powder and electroplated, thereby creating a *negative* copy of the wax, called the "master" record. By successive electroplating steps, duplicates of the "master" are obtained. These are known as "stampers," from which large quantities of playing records may be pressed. By taking the proper precautions during these processes, the acoustical fidelity is preserved.

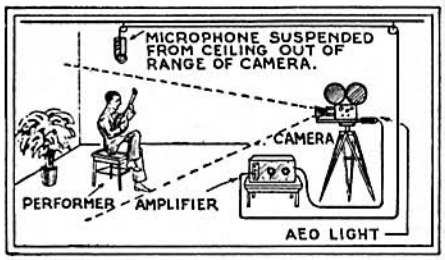

Fig. 2

The set-up for a "talkie" studio; the microphone connects through the amplifier with the apparatus of Fig. 1, which is in the base of the camera, and operates on the unexposed side of the synchronous film.

Installing "Talkies" In a Small Town

By ROBERT HAVILAND

WHEN the local house installed talkies, I did quite a bit of the electrical and mechanical work. Numerous special problems arose, and it was usually necessary to consult an expert. If the Service Man has a knowledge of some of the problems, he is in a position to make more money.

Sound on film is hardly practicable for small houses, because of its price and the technical and mechanical difficulties. However, there are several medium-price ($1,000 to $2,000) outfits on the market.

There are two types of disc machines: the first drives the projector, the second is driven by the projector. The Vitaphone is usually chosen to represent the first, and some smaller outfit, such as the Mellophone, is taken for the second type. The first sells for about $10,000 complete, and the second for about $1,000. There is some difference in tone, and much in amplifier capacity.

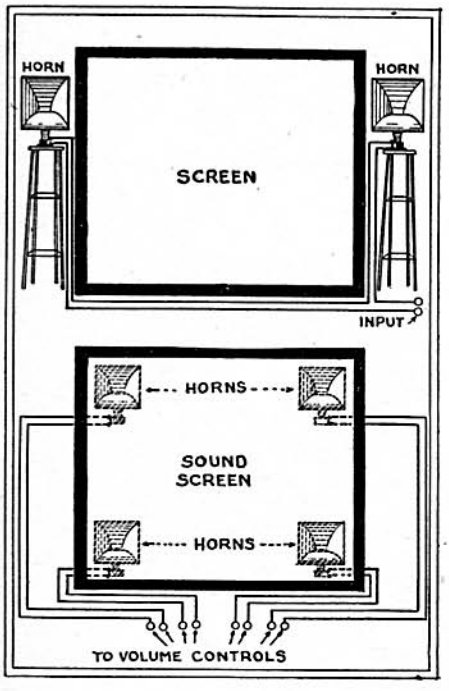

Fig. 2

Two arrangements of the reproducers in a theater; two horns may be separated by the screen, but it is better to put four behind a porous ("sound") screen.

The disc is a 16-inch record, turning at *about* 33 1/3 R.P.M.; the record tracks from the center to the edge. The film runs through the machine at the rate of 90 feet per minute. The main drive shaft turns at 90 R.P.M.

The auditorium of the house here is 65 x 22 x 11 feet; according to the rule below, no acoustical treatment was necessary. However, the back wall was covered with acoustical "Westfelt." It was found that the sound was improved, with an audience below the average, and that noise from the projection room was reduced.

(The rule for determination of acoustical treatment, given through the courtesy of the Western Felt Works, is:

Find the total "effective audience" by a formula which adds to the average number of persons in the hall on an ordinary night, one for each ten square feet of tapestry, seventeen feet of carpet, three empty upholstered chairs or 14 empty plain chairs. This is to give the equivalent *sound absorption* of the contents of the theatre. The acoustic felt absorbs as much sound as one person, with 22 square feet of 1/4-inch material, or 12 square feet of 1/2-inch. The "effective audience," thus found, is subtracted from the quotient of the number of cubic feet, in the auditorium, divided by 150. The remainder is then multiplied by 12, to get the number of square feet of 1/2-inch material needed to equalize the acoustic conditions.)

A Samson "PAM 17" was used for the amplification; the house is small, so that this model was found to give ample volume. Bigger houses require a larger amplifier; any manufacturer will supply data. It is necessary to add input, output, and impedance-matching transformers, switches and faders to any self-contained amplifier. A volume indicator is very helpful at all times.

The turntables were located under the lamphouses of each machine; a larger motor or weighted turntable will reduce the "flutter." Twisted leads were run from the pick-ups to the fader, and from the fader to the amplifier. (*Illustrations of apparatus, fully explaining all terms, are contained in the articles on Modern Sound Projection, which began in the February issue of* RADIO-CRAFT.—Editor.) It may not be necessary to shield these, but this reduces pick-up of A.C. hum from the supply line to the projector; LBX, with a flexible, braided cover, is excellent.

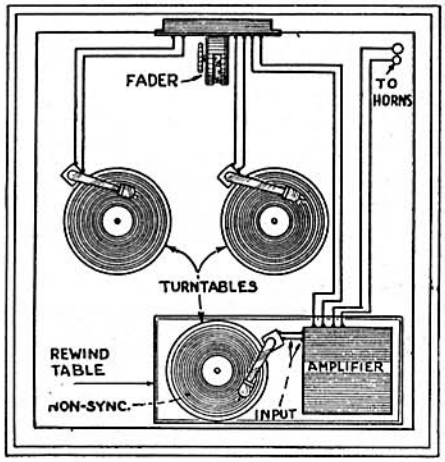

Fig. 1

Arrangement for the sound-on-disc apparatus of the booth as wired by Mr. Haviland. It may be seen that compactness was necessary.

Low-priced faders cut off the frequencies necessary for best reproduction. Amplifiers fall off in amplification on the high and the low frequencies; if the output impedance

(*Continued on page 535*)

"Talkies" in a Small Town

(*Continued from page* 520)

of the fader does not match the input impedance of the amplifier, these frequencies will be even more reduced. A constant-impedance fader decreases the resistance from pick-up to amplifier as it is turned on; but it does not change the resistance across the pick-up or amplifier terminals.

To switch in the "non sync," a D.P.D.T. switch is used; two non-sync turntables may be used with a fader between. Fig. 1 shows the general layout, omitting the projectors.

The output of the amplifier is fed through a Samson "012" transformer into another pair of twisted leads. (In large houses, a rack-and-panel installation is best.) This pair of leads is connected through the output panel by parallel leads to each speaker. Each lead should have its own volume control of the constant-impedance type, of course.

The speakers used are two Temple "Air-Chrome," a large one for low notes and a smaller one for the high frequencies. Dynamics could be used, but I never could understand the fuss over dynamics. If you use horns, take a tip from W. E.; they use a small horn for the high notes, and two larger horns for the low notes. It seems that the small horns have a high cut-off frequency, while the larger ones suppress the high notes because of their very long air column.

The two speakers are placed on either side of the screen (as shown in Fig. 2), giving good illusion. If four speakers are used, a "sound screen" is necessary. The speakers are adjusted for volume and angle until the reproduction is best; the volume should be as low as possible. Installation is largely a trial-and-error method.

GROUNDING THE BOOTH

By R. E. Norris

SOME time ago the local theatre man decided to install an amplifier and disc apparatus to furnish music for his theatre; and I, as the local Service Man, was naturally called into consultation. Mr. Theatre Man was easily convinced that his equipment should be bought with the idea of utilizing it later for talkies.

With record amplification, we had no trouble; but, when he bought the "talkie" equipment, our difficulties started.

First, the arc lights had to be changed to Mazdas; then, we found that we could get no volume out of the pick-ups through the fader attached to the metal-lined walls of our booth, though we used standard porcelain insulators and plenty of separation between wires. We were in touch with various parts manufacturers who, in all fairness it must be said, tried to help us as much as they could. We also talked to several experts in nearby cities without results. Finally, as a last resort, the idea occurred to us to ground the lining of the booth—and the job was done! Not only did our volume from the machine fader come up, but our speaker controls, local and remote, then behaved as they should.

Another trouble we encountered was poor reproduction of music from the discs, which