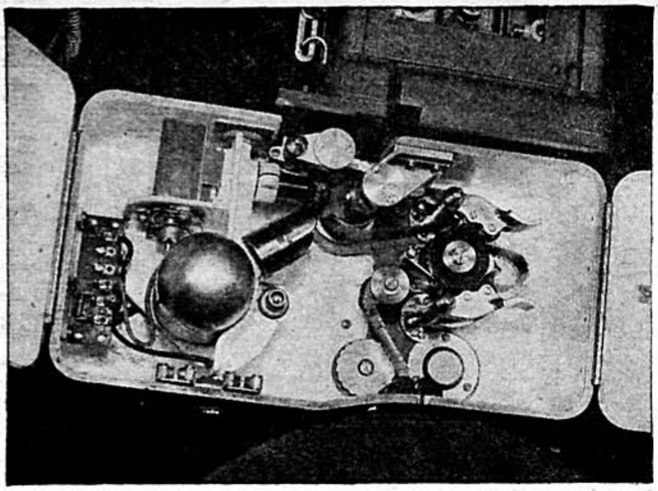
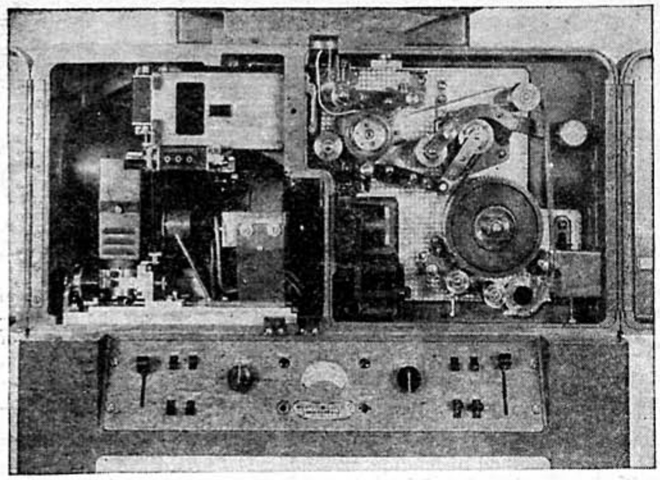


Mirrophonic reproducer. Lamp and lens-hood may clearly be seen. The photo-cell goes behind film in cylinder at oblique end of lens-hood.



Photos Courtesy Electrical Research Products Inc.

Recorder interior. Left-hand portion contains lamp and light valve. At the right may be seen the mechanical film-propelling apparatus.

NOISELESS RECORDING

By I. QUEEN

BACKGROUND-free recording of film sound, with highest fidelity and widest dynamic range, is possible if one has knowledge of both electronics and photography.

Three principles in sequence, Fig. 1, are; Sound, (a) converted to EMF controls light source (b) to expose film (c) to a series of recorded vibrations of exposure. Film is then processed (Step Two). In playback, (Step Three), (a) constant light source monitors variations of exposure on film (b) passing them so they strike photo-cell (c) which produces EMF (d) which is amplified and then reproduced. Transformations must be linear to avoid distortion.

Film comes in two sizes, "standard" 35mm. (width), and "amateur," 16mm. Large theatre projection uses 35mm., while small theatre and homes use 16 mm. The 35mm. has advantages as follows; for high frequencies the light variations will be very closely spaced along the film if the latter moves slowly. Since the larger film has a linear speed of 1½ ft./sec. (2½ times as fast as the 16mm. film) it will obviously have a better response. Also, because of the greater width, more light may pass through the track and less amplification is required. Finally, scratches and dust on the track introduce correspondingly less noise on the 35mm.

Fidelity in reproduction requires that the constant light be modulated by the film exactly in accordance with the original sound. For this, a very thin slit (as wide as the track) is placed in front of the film. The total amount of passed light must vary with the instantaneous sound pressure of the original acoustic energy. This equals the product of average transparency of film by the slit area.

Two general methods may be used to modulate the light. Firstly, Fig. 2, to decrease it by 50% we may either maintain the transparency of the film, decreasing by 50% the slit area, or, as in Fig. 3, we may allow light to pass through the entire slit area and decrease by 50% the transparency.

VARIABLE AREA SYSTEM

This method uses a vibrating galvanometer suspended in a strong magnetic field, a tiny mirror reflecting the constant light source onto the film in accordance with the A.F. (See Fig. 4.) For original adjustment only half the aperture area is illuminated. Modulation alternately increases and decreases the exposed area so that maximum corresponds to variation from zero to full. Theoretically, the smaller the height of the slit the better the fidelity. In practice the height is less than .001 inch. Film recorders use optical systems which focus down the mechanical slit to obtain this small opening. By resonating the entire galvanometer system to a very high audio frequency we get a constant response throughout the audio range. These recorders are very rugged, require little adjustment, and have good fidelity.

VARIABLE DENSITY

Recording of this type is done by two methods. Formerly the output current of an amplifier had a quartz glow lamp to provide variable light. The tube, responding almost instantaneously to EMF variations, exposed the moving film. Only the linear portion of the lamp characteristic may be used. Outmoded because of limited output and delicate construction, this method is still the ideal for amateur work.

Outstanding fidelity and stability are obtained by the light-valve recorder, Fig. 5. Two duraluminum ribbons are positioned in a magnetic field. A.F. currents passing

(Continued on page 320)

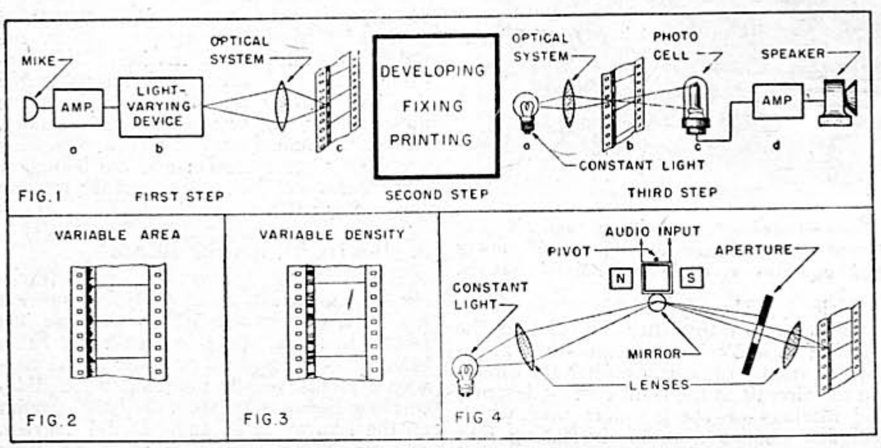
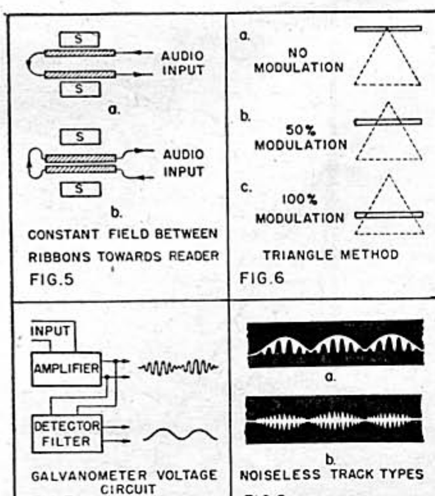
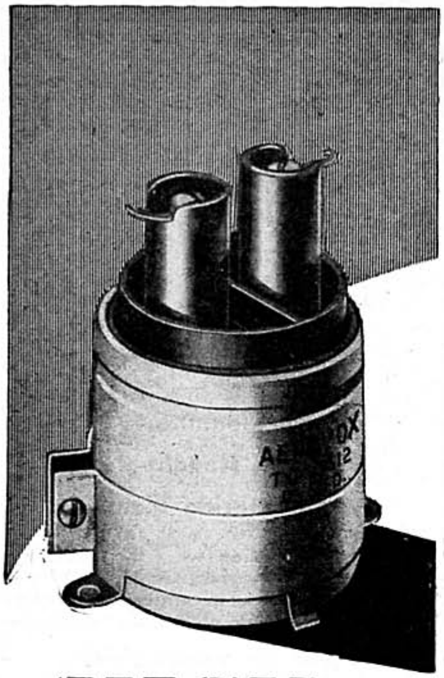


Fig. 1—The three steps of reproducing movie sound. Fig. 2, 3—Variable-area and variable-density film. Fig. 4—One recording system using an oscillating-galvanometer-modulator.





NOISELESS RECORDING (*Continued from page 274*)

through produce vibrations, the ribbons being alternately attracted and repelled.

Assume a constant magnetic field. When the additional field (due to current) adds to the constant field, the ribbons separate (5-a). When one opposes the other, the ribbons approach (5-b). Full modulation is obtained when they touch and open to twice normal separation alternately. This is disadvantageous, since overload causes ribbon clash and possible damage. Also, distortion is introduced due to the slit height not remaining constant. The previously-mentioned caution—transformations must be linear—applies here.

Noise during quiet intervals is due to fine grain, scratches, and dirt on the transparent areas. Fig. 6 represents a typical "noise-free" system using the triangle variable area method, similar principles being applicable to all types.

The luminous triangle is mounted on a galvanometer, free to vibrate vertically. Exposure is obtained only from that area at the slit. The galvanometer has two windings, one for the A.F. input, the other for a biasing D.C. potential which follows the envelope of the first. The latter is obtained from the original A.F. by detection and filtering, similar to the manner in which an AVC voltage is produced from modulated R.F. in a radio receiver.

During silent intervals, there is no biasing voltage and the triangle is at position A. At 50% modulation, the D.C. obtained from the audio voltage biases the galvanometer so that the triangle assumes position B (and vibrates about this mean position). At full modulation the average triangle position is at C, where it may vibrate from one extreme to the other. Thus, only sufficient transparent areas to carry the necessary modulation are placed before the photocell. During periods of no input the track is therefore opaque.

PHOTOGRAPHIC ANGLES

Certain principles of photography must be followed. Much difficulty is eliminated by using two separate films, one for the picture, the other for the sound.

When a film coated with silver bromide crystals is exposed to light and suitably processed, it darkens, the crystals changing to metallic silver. The still transparent (unexposed) areas are maintained by placing the film in a hypo solution which causes loss of sensitivity to light. The film is therefore a negative and may be printed by placing between an unexposed film and a source of light. Obviously the latter film will be a positive.

Now the film must darken in proportion to the light striking it. Film laboratory technicians make use of a curve (H & D curve) plotting density vs. logarithm of exposure for the given film. These curves exhibit a middle linear portion and are non-linear at each end. By definition, density equals logarithm of opacity, so the plot is really opacity vs. exposure, and we require a straight-line characteristic. The slope (gamma) of the curve determines film contrast and varies with developing time, exposure, type of film, etc.

TESTING THE NEGATIVE

Variable-density film has an output determined by its contrast (gamma) which must be maintained essentially constant. To determine correct gamma, test strips are recorded, developed to different gammas, printed and projected to find which results in least distortion and sufficient volume.

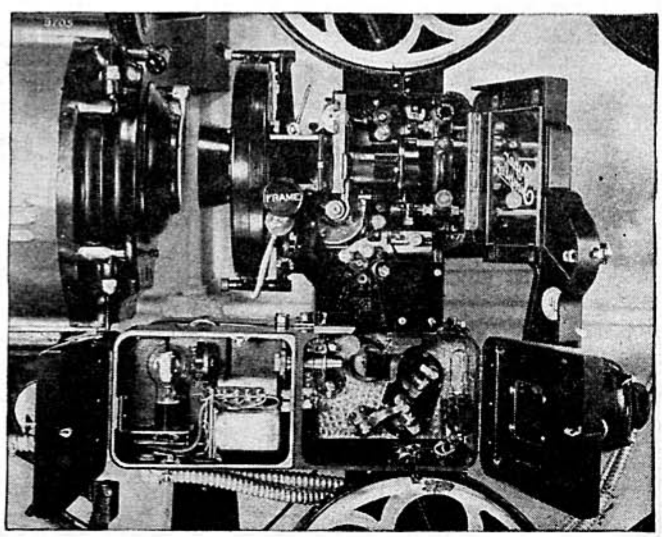
The variable-area film is not concerned with contrast, there being present only an area of opacity and one of transparency, so that only the density must be controlled, a comparatively simple matter. A density of 1.6 on the negative, about 1.4 on the positive is usually attained, but this is not critical. Direct reading densitometers, (Eastman Kodak type) are available.

The sound output depends upon difference in density between the light and dark sections of the track. The obtainable density is limited by the nature of developing chemicals which cause "fog" should we process the film too long in an effort to obtain a higher density value. A fog density not greater than .04 on the transparent area is permissible. If greater, the high frequency modulations will fill in and become lost.

It is good practice to record test strips containing sibilant or "s" sounds, since they are usually lost first. The strip having least distortion and adequate volume is noted for density, developing time, value of recording light brilliancy, etc., and can be used for a guide.

The volume varies as $20 \log (T_1 - T_2)$ where the subscripts refer to the clear and exposed transparencies respectively.

An interesting fact is that a film negative sounds like a film positive since the same variations of exposure (in transposed order) are present. However, a characteristic distortion will be present on the former, because the actual change from a transparent to an opaque area does not take place sharply. This gradual change takes place



Interior of projection mechanism. Lower section in rectangular housing is sound reproducer. Note the tubular incandescent lamp at extreme right, which projects image of sound track through lens system in partition to photocell at extreme right.

—Photo Courtesy Electrical Research Products, Inc.

in reverse sense on the positive and is cancelled. Sibilant sounds are especially affected.

RECORDING TECHNIQUE

Hollywood synchronizes camera and recorder with complicated Selsyn motors. The small studios use simple inexpensive motors, synchronic only at high speed, which can operate both off the same line. Action here begins when high speed is obtained through a technique which in the profession is called clacking.

Before a "take", an assistant stands in the camera field with a book or "clapstick" which he slams shut on receiving signals from cameraman and recordist that their motors are up to speed. The picture frame which shows the clapstick just closing corresponds to the track modulations of the sharp report.

As in all recording and broadcasting, apparatus limitations require that the sound be kept high enough to be above noise level and low enough to avoid over-modulation. The sound man therefore manipulates the gain control to obtain a smooth, faithful record, although the average level has been carried up or down.

Special noise-eliminating precautions must be taken. Quiet running machinery is essential and noise-proof booths may be used to house the camera and recorder, the picture being taken through a glass window. Soundproofing the studio eliminates echoes and reverberation.

Since it is easy to distinguish close-up from distant sound, it is essential to fit the sound to the scene. Obviously a close-up picture accompanied by a far-away sound is ridiculous and disagreeable. Each type of sound has a different ratio of original to reflected energy and the nearer sound has a greater proportion of lower to higher frequencies. A change of scene almost always calls for a change in microphone position.

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THAT 11-TUBE SUPERHET

It has been pointed out that the plate circuits of the two sections of the 6K8 in Emmett Brightwell's 11-tube superheterodyne, printed on page 156 of the December, 1944, issue, were interchanged in the drawing. The oscillator and converter plates are actually connected in the orthodox fashion. A decimal point also dropped out of the "0.1-mfd" indicating the condenser between A.V.C. line and ground. This makes it 1 mfd, much too large for an A.V.C. circuit. Another decimal point dropped out in the designation of one of the cathode by-pass condensers, but in this case use of the larger size would make no difference.

Our thanks are due to Mr. J. M. Sherman of Troy, Ohio, who pointed out these errors to us.

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THE ELECTRONIC BAT

AUTOMATIC electronic safety devices which will bring a car to a stop when an object looms up before it were predicted last month by Kenneth W. Jarvis, Chicago consulting engineer.

Speaking to the RMA and IRE convention in that city, he showed how a sound-receiving and projecting device could control brakes and gasoline feed, determine distance to the nearest object ahead of the car, slow it down and bring it to a complete stop if necessary to prevent a collision.

The humble bat, equipped for supersonics, has used this collision-prevention system with excellent results for many milleniums.