

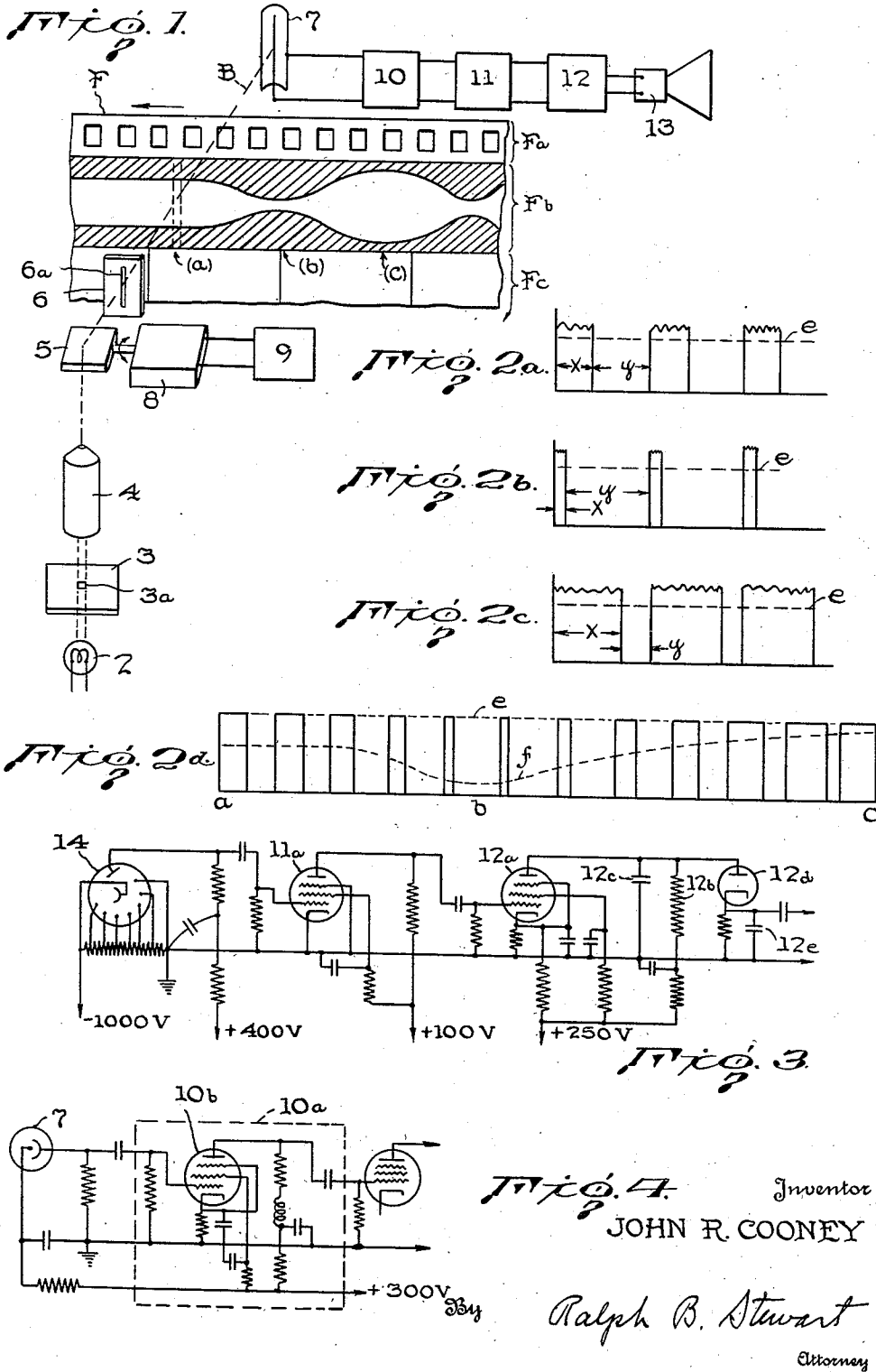
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NOISELESS SOUND SYSTEM

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NOISELESS SOUND SYSTEM

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This invention relates to a sound reproducing system and in particular to a system for reproducing sound from a sound record of the photographic film type.

In reproducing sound from photographic films, one difficulty has been the presence of noise in the reproduced sound caused by irregularities, imperfections, graininess, etc., of the film on which the sound has been recorded. The reproducing systems heretofore employed have been equally affected by the extraneous variations and by the sound record, and the elimination of this extraneous noise has been the source of much study and effort.

In present day equipment for the reproduction of sound from film such as that commonly employed in motion picture studios, the usual method of minimizing the effect of the extraneous noise is to mask out the noise by a strong signal. In other words, the recording systems are designed to produce a high signal-to-noise level at all times. In systems employing a sound record of the variable area type, the width of the track on which the sound is recorded is varied so that it is never any wider than is necessary to accommodate the signal strength at any instant. In the systems employing films having a sound record of the variable density type, the same effect is obtained by keeping the average density at the minimum allowable at all times. In either case, the noise reduction is accomplished by rectifying part of the signal being recorded, and the resulting direct current is employed to operate the noise reduction shutter in the case of a variable area record, or a light-valve bias in the case of a variable density record. It will be recognized that these noise reduction procedures do not eliminate the source of trouble, and the noise is still noticeable as an accompaniment to other modulation, especially in the case of pure tones of large amplitude. Furthermore, the noise reduction technique itself produces various detrimental effects on the sound which are serious enough to warrant continued search for better methods.

The present invention is concerned with the reproduction of sound from a film having a sound record of the variable area type.

An object of the invention is to devise an improved method of reproduction whereby the extraneous noises due to the causes mentioned above are substantially eliminated. My improved method of sound reproduction will eliminate the extraneous noise from films recorded by the usual "noise reduction" procedures or from

films having a simple variable area track recorded without the noise reduction procedure.

Another feature of my invention is that within certain limits, my reproducing system is not affected by variations in the intensity of the light source.

According to my invention, instead of following the usual procedure of passing a beam of light through the sound track and intercepting the beam by a photoelectric cell which produces a current output which varies with the amount of light passed by a small linear section of the film, I have devised a system in which the output current varies in accordance with the relative amounts of black and clear area in each small linear section of the sound track. In other words, the output current varies in accordance with variation in position of the boundary line between the black and white areas, and is not dependent upon the amount of light passed by the film. Each location of the boundary line produces a definite output which is independent of the imperfections of the film carrying the record and is independent of variations in the light source, within certain limits.

The object of my invention is accomplished by scanning the sound track by a beam of light having a very small cross-section, the beam being moved transversely of the sound track at a very high scanning rate in substantially the same manner as the scanning process in a television system. A photoelectric cell is influenced by the scanning beam after passing through the film, whereby current impulses are generated in the cell having a frequency equal to the scanning frequency. The duration of each current impulse is dependent upon the width of the clear area in the sound track at any given point of scanning. The amplitude of each current impulse will vary somewhat depending upon the imperfections carried by the film, and these variations would be reproduced as noise if the resulting impulses were integrated and supplied to the loud speaker. In my system, however, the current impulses from the photoelectric tube after being amplified are passed through a current limiter which serves to eliminate all of the variations due to film imperfections, and the current impulses appearing at the output of the current limiter are all of the same amplitude but the duration of each pulse is dependent upon the width of the corresponding clear area in the sound track. These current pulses of uniform amplitude but of variable duration are then integrated and supplied to a sound reproducer to

produce an audible signal which is substantially free from the usual extraneous noises.

Certain apparatus for carrying out the invention is diagrammatically illustrated in the accompanying drawing in which

Figure 1 is a diagrammatic view in perspective showing one arrangement for scanning the sound track on a motion picture film, and also showing the essential elements in a circuit for amplifying, limiting and integrating the impulses produced by the photoelectric cell;

Figures 2a, 2b and 2c are curves showing the form of current pulses for different sections of the sound record;

Figure 2d is a curve showing a series of current pulses representative of the pulses produced over a certain linear section of the film;

Figure 3 is a circuit diagram involving an electron multiplier type of photo-cell connected to a limiter tube and a detector tube; and

Figure 4 shows one example of a wide band amplifier for amplifying the photoelectric current impulses.

Referring to Figure 1, I have shown a fragmentary section of a film F arranged to travel in a horizontal direction as indicated by the arrow, although it may be arranged to travel in a vertical direction if desired. The film is of well known motion picture type consisting of an outer section Fa carrying the sprocket apertures, a sound track section Fb, and a picture section Fc only a portion of which is shown in Figure 1. The crosshatched portion of the sound track represents the blackened or dark portion of the track.

Instead of projecting a narrow beam of light through the sound track in the usual manner, I project a small beam or pencil of rays through the track which covers only an elementary area of the track at any given time, and this beam is caused to traverse the sound track at a rapid rate while the film moves in the direction along its length. The small scanning beam may be produced by well known means, and in Figure 1 I have represented a suitable source of light by the lamp 2, which may be of the well known "crater" type of lamp. Rays from lamp 2 pass through an aperture 3a formed in a shield 3. A suitable optical system 4, involving one or more lenses, is provided to concentrate the beam of rays passing through aperture 3a and to direct the beam against mirror 5. The beam is reflected from mirror 5 and directed through an elongated aperture 6a formed in a shield 6, the aperture 6a being arranged at right angles to the axis of the film track Fb. The scanning beam passing through aperture 6a is directed through the film track and falls on a photoelectric cell 7 positioned behind the film F. The aperture 6a is formed so that the scanning beam B contacts the film only in the area of the film track, and the beam is cut off by the shield 6 when the beam is deflected beyond the side boundaries of the film track. The scanning beam is concentrated so that it covers only an elementary area of the sound track, for example the area covered by the beam on the film may be a square area measuring 0.001 inch on a side. The mirror 5 is mounted to be vibrated in a direction to cause the beam B to travel along the axis of the aperture 6a at a relatively high rate. Any suitable means may be employed for this purpose, but for the purpose of illustration, I have shown the mirror as being mounted for vibration by a piezo crystal unit 8 (such as a Rochelle salt crystal or

a quartz crystal). The crystal unit is supplied with exciting voltage from a suitable source of alternating current 9, such as a vacuum tube oscillator. The frequency of scanning the sound track preferably is above audibility; for example, the source 9 may have a frequency of twenty kilocycles or above.

The circuit for photo-tube 7 includes an amplifier 10, a current limiter 11, an integrator or detector 12, and a signal reproducer or loud speaker 13. The unit 12 may also involve an audio frequency amplifier.

Operation of Figure 1 is as follows: Assuming that oscillator 9 has a frequency of 25,000 cycles per second, the scanning beam will sweep across the sound track Fb two times for each cycle or 50,000 times per second. During the time when the beam is passing through a clear portion of the sound track, a current is established in the cell 7 which has an amplitude dependent upon the intensity of the beam, the area of the beam, the opaqueness or clearness of the film, and the constants of the cell circuit. The length or duration of each current pulse will depend upon the time required for the beam to traverse the clear section of the film. It is preferred that the beam travel at a nearly uniform rate throughout the length of aperture 6a, so it will be assumed that the beam travels beyond the end of aperture 6a at each end.

In the position of the film shown in Figure 1, and with the mirror 5 vibrating at a frequency of 25,000 cycles per second, then the cell 7 will set up current pulses at a rate of 50,000 per second. The current pulses at the point a on the sound track are represented by the curve shown in Figure 2a. Here the duration of the pulse represented by the distance x is proportional to the width of the clear portion of the track at a. The distance y, representing the periods of no current, is determined by the time required for the beam to travel beyond the edges of the clear portion of the sound track to the end of its swing and back to the edge again. The irregular shape of the pulses at the top represents variations caused by noise sources.

As the film moves along its path from point a to point b, the duration of the pulses decreases, and the periods of no current increase, until at the point b the pulses are as indicated in Figure 2b. As the film proceeds from point b to point c, the duration of the pulses increases, and the periods of no current decrease until at the point c the pulses are as shown in Figure 2c.

In all cases, the current pulses in passing through the limiter 11 have their amplitudes limited to a predetermined value represented by the horizontal line e in Figures 2a, 2b and 2c, thus eliminating the noise variations in each pulse.

In Figure 2d there is shown a series of pulses representative of the pulses which would be produced between the points a and c in Figure 1, as they will appear at the output of the limiter 11. These pulses will be integrated by the detector 12, and the resultant current will have a wave form like the curve f shown in Figure 2d which corresponds in shape to the shape of the clear portion of the sound track between the points a and c in Figure 1. This resultant current may be amplified before being supplied to the loud speaker 13, and the reproduction by the loud speaker will be free of the noise variations which were eliminated by the current limiter 11.

Suitable apparatus is known in the art for use in units 10, 11 and 12 for amplifying, limiting and

integrating the current pulses produced in the cell 7. For amplifier 10 I prefer to use a wide band amplifier with a sharp cut-off below the scanning frequency.

The scanning arrangement shown in Figure 1 is simply for the purpose of illustration, since other known scanning arrangements may be used. For example, a rotating mirror drum may be employed to sweep the scanning beam across the sound track instead of using the vibrating mirror shown. Also, known scanning systems used in the television and picture transmission art may be employed. For example, the film track may be scanned by an "iconoscope," and the current variations derived from the scanning would be translated in the same manner as in Figure 1. In such an arrangement an image of the sound track is projected onto a photosensitive mosaic, and the mosaic is scanned by an electron beam moving transversely of the sound track. The optical image of the sound track projected on the mosaic may be limited to a single transverse elementary strip or else the electron beam would be limited in cross-section to the size of an elementary area of the image. Also, an electronic scanner of the type developed by Farnsworth may be employed if desired. In such an arrangement an optical image of the sound track is translated into an electron image, and the electron image is scanned or shifted back and forth over the aperture in a shield plate positioned in front of the electron collector electrode.

In Figure 3 I have shown the circuit diagram of a suitable photo-cell circuit employing a cell of the electron multiplier type. The circuit also involves an arrangement for converting the pulses of variable width into pulses of variable amplitude and variable width. In this arrangement the photo-cell 14 may be a cell of the type No. 931 with the necessary energization circuit. The output of this cell is coupled through a suitable network to the control grid of limiter tube 11a which conveniently may be a tube of the type 6SJ7. The output of the limiter is connected through a suitable network to the control grid of a tube 12a which is normally biased to cut-off. The plate circuit of the limiter includes a resistance 12b which normally charges a condenser 12c connected between the plate of the limiter and the grounded lead of the circuit. The output circuit of the limiter is connected across condenser 12c and includes a diode 12d connected in series with a condenser 12e.

The operation of Figure 3 is as follows: The action of photo-cell 14 in amplifying the photoelectric effect is well known. The advantage in using this type of cell is that it avoids the complication involved in the use of a wide band amplifier which would otherwise be necessary. Also, the use of electron multiplication avoids the amplification of external influences which might be amplified by a wide band amplifier, such influences conceivably originating in the crystal oscillator circuit or in other nearby electrical disturbances. The impulses delivered by the cell circuit to the limiter 11a are generally of the shapes indicated in Figures 2a, 2b and 2c, and the impulses delivered by the limiter to the tube 12a have the same general shape as the impulses shown in Figure 2d. Tube 12a serves to convert the pulses of variable width into pulses of variable amplitude. Positive pulses impressed on the grid of tube 12a cause the tube to become conductive, thereby discharging condenser 12c and maintaining this condenser discharged until the signal

ceases or goes negative. When the signal ceases, condenser 12c is charged at a uniform rate through resistance 12b. The voltage across condenser 12c is, therefore, a saw-tooth wave, the peak amplitude of which is proportional to the width of the periods of no signal or to the width of the negative pulses. Condenser 12e is charged to the peak value of the saw-tooth wave through diode 12d, and the voltage developed across 12e is therefore a measure of the width of the original pulses. The variable voltage developed across condenser 12e is impressed on a suitable audio frequency amplifier and is then translated into sound by a suitable sound reproducer. By properly selecting the constants of the circuit, the audio signal may be reproduced with no appreciable distortion.

In Figure 4 I have shown one example of a suitable wide-band amplifier for amplifying the photoelectric currents from a simple cell 7. A single stage of the amplifier is indicated within the dotted rectangle 10a and it employs a pentode 12b. The amplifier represented at 10 in Figure 1 may consist of a number of these stages connected in cascade in front of the limiter. This amplifying arrangement may be designed to cover a frequency range from 50 kilocycles to one megacycle, with a sharp cut-off below 50 kilocycles.

What I claim is:

1. A method of reproducing sound from a sound track on a record which comprises scanning the sound track in elementary paths transversely of its length, establishing a current pulse for each scanning path, the amplitude of each pulse being dependent upon the transparency of an elementary area of the scanning path at any instant, translating said pulses into pulses of limited uniform amplitude, integrating said translated pulses into a variable current, and translating said variable current into sound.

2. A method of reproducing sound from a sound track on a record which comprises establishing a series of current impulses varying in amplitude in accordance with the transparency of successive elementary areas in transverse paths across said sound track, one pulse being established for each transverse path in said sound track, limiting the amplitude of said pulses to a predetermined value, integrating said limited pulses to produce a variable current, and translating said variable current into sound.

3. A method of reproducing sound from a sound track on a record which comprises scanning the sound track according to elementary paths transversely of its length, establishing a current pulse for each scanning path, the value of each pulse varying in accordance with variations in transparency of successive elementary areas of the respective scanning path, and the length of each pulse corresponding to the width of the clear portion of the sound track at the point of scanning, transmitting said pulses through a current limiter to limit the amplitude thereof, translating said amplitude limited pulses into a variable current, and translating said variable current into sound.

4. A method of reproducing sound from a sound track on a record which comprises scanning the sound track according to elementary paths transversely of its length, establishing a current pulse for each scanning path, the value of each pulse varying in accordance with variations in transparency of successive elementary areas of the respective scanning path, and the

length of each pulse corresponding to the width of the clear portion of the sound track at the point of scanning, transmitting said pulses through a current limiter to limit the amplitude thereof, translating said limited pulses into pulses having amplitudes proportional to the lengths of the corresponding scanning pulses, translating said variable amplitude pulses into a variable current, and translating said variable current into sound.

5. Apparatus for reproducing sound from a sound track on a record comprising, in combination, means for scanning a sound track in ele-

mentary paths transversely of its length and establishing a current pulse for each scanning path which varies in amplitude in accordance with the transparency of the successive elementary areas in the corresponding path, a current limiter, means for transmitting said variable pulses through said limiter whereby the amplitudes thereof are limited to a predetermined value, means for integrating said limited pulses into a variable current, and means for translating said variable current into sound variations.

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