June 4, 1929. R. J. POMEROY 1,715,863

SOUND RECORDING AND REPRODUCTION

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Fig. 1

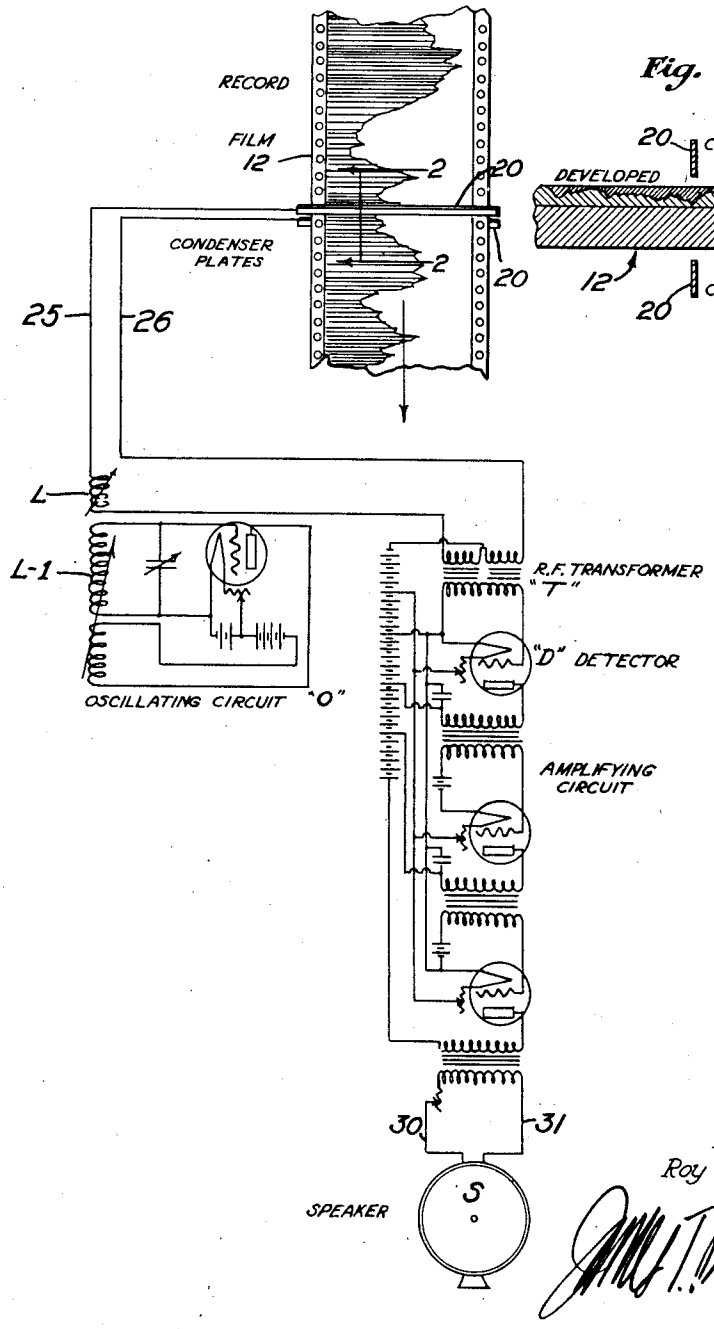
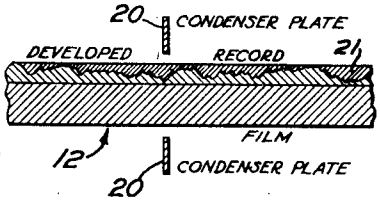


Fig. 2



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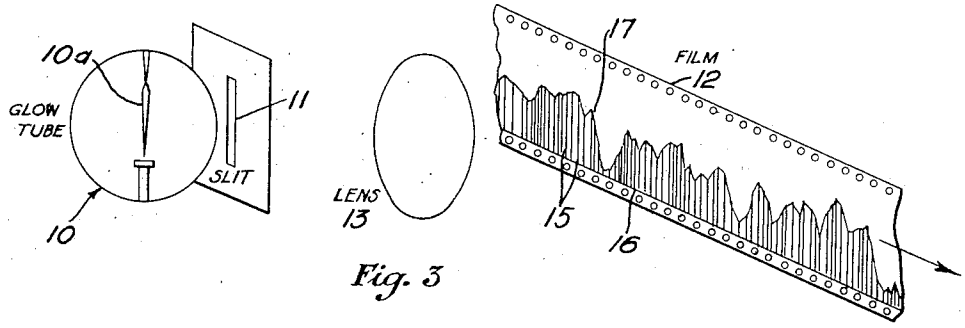


Fig. 3

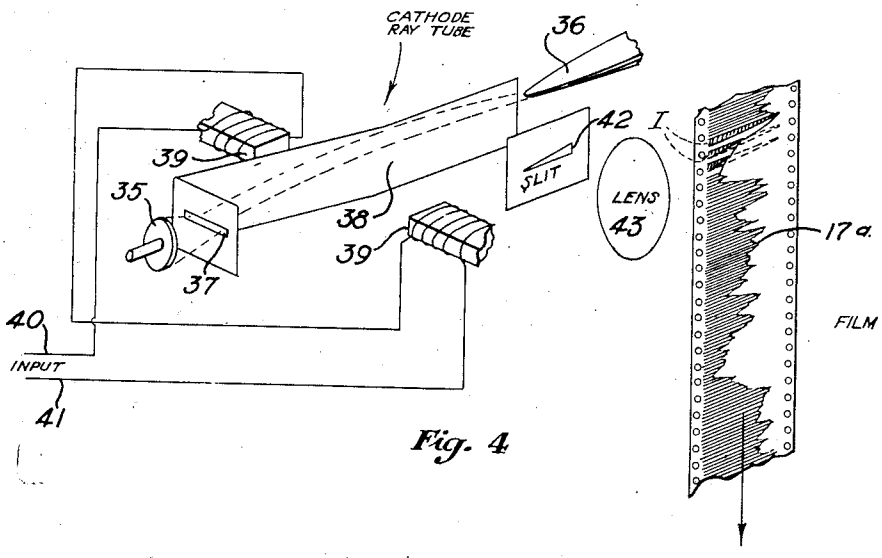


Fig. 4

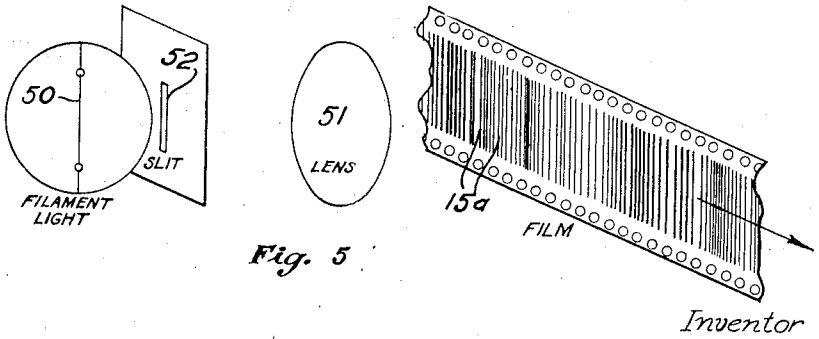


Fig. 5

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Fig. 6

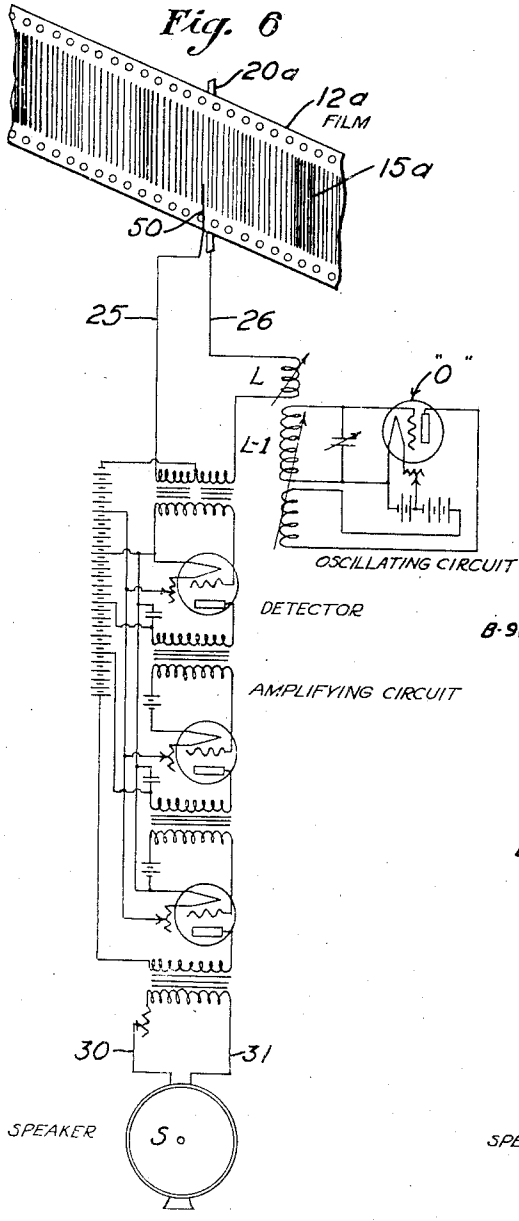
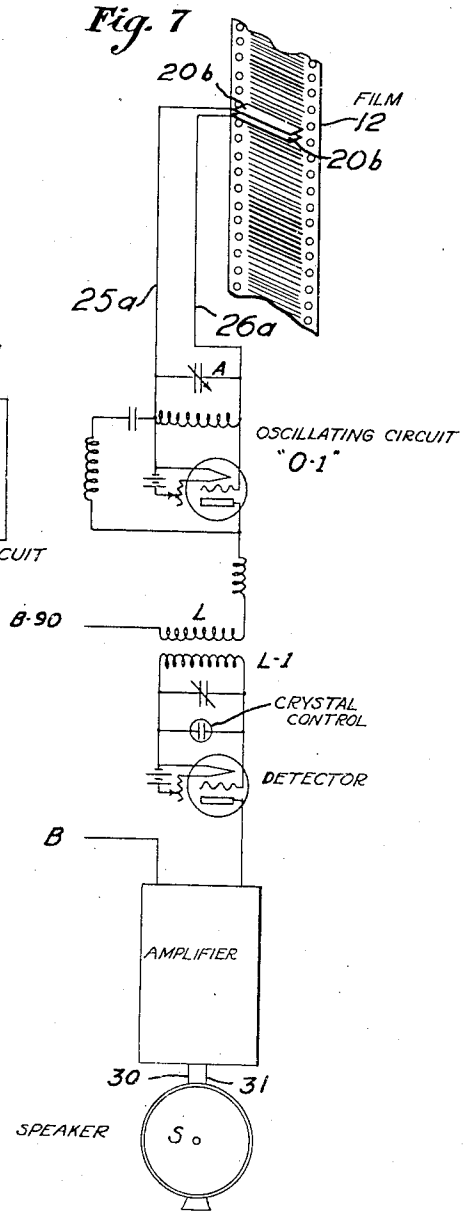


Fig. 7



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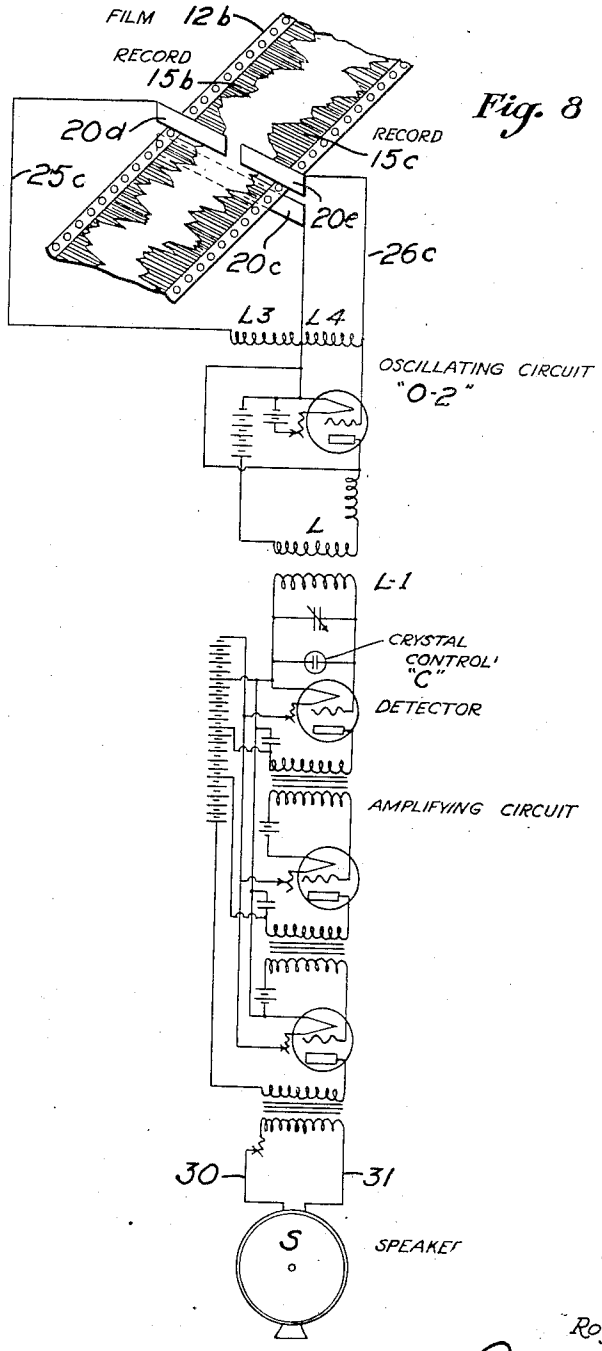


Fig. 8

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UNITED STATES PATENT OFFICE.

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SOUND RECORDING AND REPRODUCTION.

Application filed August 9, 1927. Serial No. 211,834.

This invention has to do with the recording and reproduction of sound; and the invention is best exemplified as a system using a sound record of the photographic type, the invention making use of certain characteristics of that type of sound record which so far as my knowledge goes, has not heretofore been used for sound reproduction.

As is well understood in the art, photographic sound records have been produced in various manners and have then been reproduced by subjecting a selenium cell or a photoelectric cell to a beam of light intercepted and modified by the photographic sound record, thus making use of the varying light transmissivity of such record.

In contradistinction to all the past practices of which I am aware, my system first provides a sound record that has what may be termed a varying capacity, or a varying di-electric characteristic, and then make use of those varying characteristics to vary the effective capacity of a condenser assembly, using such resulting varying condenser capacity for actuating a system which includes a sound vibration producing element. The actual final production of sound in this sound vibration producing element may typically be in the form of a speaker, and the system may also include oscillating and amplifying circuits which feed the speaker.

Although my present system is not necessarily limited to the use of photographic sound records such as are now known, requiring only a record in which the sound vibrations are represented by record parts or elements having a varying di-electric or capacity characteristic, the invention may well use, and is at present most readily illustrated by use of, certain types of photographic sound records. Consequently in describing the invention I shall illustratively describe the use of certain types of such photographic sound records.

In the drawings:

Fig. 1 is a diagram illustrating a complete reproducing system;

Fig. 2 is an enlarged diagrammatic section taken on line 2—2 of Fig. 1;

Figs. 3, 4 and 5 are diagrams indicating several typical manners in which the record may be made.

Figs. 6, 7 and 8 are diagrams illustrating modified manners of using other types of record.

In order to describe a typical record I shall refer first to Fig. 3. Here a glow tube is indicated diagrammatically at 10. In producing a record this glow tube will be energized in a circuit whose potential varies in accordance with the sound vibrations wished to be recorded. Systems for thus operating a glow tube, or a source of illumination of any character, are so well known as to need no description here. Typically such system may embody a microphone which receives sound initially, the current from the microphone being amplified through an amplifying circuit and the glow tube fed from the output of that amplifying circuit. The nature of the glow tube is such that with variation of potential the glow indicated at 10^a in Fig. 3 varies in length. A slit such as indicated at 11 may be used in connection with such a tube so that the image cast upon film 12 by lens 13 will be of constant width, the width controlled by the slit, and of varying length. Thus, presuming that film 12 is moved lengthwise in the relative direction indicated, it will, upon development, show a series of shaded images such as are diagrammatically indicated by the lines at 15, one end of all the images being in or forming a straight line as shown at 16 and the other end of the image series forming an undulating line as indicated at 17. The several images of the series may be juxtaposed, or substantially so, or they may be fairly well separated in the direction of length and movement of the film, depending upon the speed of vibration of the light in the glow tube and upon the speed of movement of the film. In any case the distance between images in the direction of movement of the film will represent the speed of vibration (the pitch of the sound), the length of the image will represent amplitude of vibration (the volume of the sound), and the curve 17 represented by the ends of the images will represent the characteristics of the sound. Also the several successive images may be, when developed, of somewhat varying density, due to the glow becoming brighter as it becomes longer. Such varying densities may therefore at least partially represent amplitude of vibration and volume of sound.

When such a record is initially developed,

and assuming for instance that an actinic emulsion containing a silver salt is used, the variations and characteristics hereinbefore described are then represented by reduced silver. The amount of reduced silver at any particular point in the whole composite image is controlled by and thus represents all of the characteristics of the initial sound. The usual method of reproduction of such a record depends upon the varying light transmissivity of such a record due to its varying local amounts of developed silver; but my method of reproduction depends, as I have said, upon other distinct characteristics of those varying amounts of reduced silver.

In reproducing such a record it may be run between two small condenser plates located on opposite sides of the film at a suitable distance from each other. These condenser plates may preferably be in the form of narrow bars or wires, stiff enough to be supported rigidly in definite relationship to each other and to the film; and preferably the width of these small plates (their dimension in a direction lengthwise of the film) will be not more than the width of a single image, or periodicity distance between images, on the film. As the film is run between these two condenser plates the effective capacity of the condenser assembly is varied because of the variation of the nature of the di-electric between the two plates. From what I have said concerning the record it will be readily understood that as the film is run between the two plates varying amounts of developed silver are at different times present between the two plates; the varying amounts of silver being due to the varying length dimensions of the several images and also due perhaps somewhat to their varying density. Fig. 2 shows in diagram, perhaps somewhat exaggeratedly, the varying thickness or density of metallic silver deposit 21.

The condenser formed by the two plates 20, with its intervening variable di-electric, is connected to the input circuit of an amplifying set, the two wires 25 and 26 of the input circuit being connected to the two plates. This input circuit will include an inductance L which is coupled with the inductance L^1 of an oscillating circuit of any suitable type, the oscillating circuit as a whole being indicated by the letter O. An oscillating current of definite periodicity is set up in the input circuit which includes the described condenser; and a sound wave is imposed upon that oscillating current by the varying effective capacity of the condenser. It is preferred to set up an oscillating current of comparatively high frequency as a given variation in capacity will cause a larger variation of current than if a current of lower frequency were used. The oscillating current with the imposed sound wave which flows in the input circuit is substantially similar to the equivalent current in a radio receiving set. The amplifying circuit will therefore include a radio frequency transformer T and a detector tube D and then as many audio frequency transformers and audio frequency amplifying tubes as may be desired. The out-put circuit 30, 31 will then finally go to some sound wave producing element, such as a speaker S. Control of the degree of amplification may of course be effected in any of the manners common to amplifying circuits, and also the magnitude or volume of the final sound production may be controlled by changing the normal capacity of the condenser assembly or by changing the oscillating frequency. It is very simple for instance to change the distance between the two condenser plates 20. But it will be understood that in any and all variations of capacity of the condenser, either by way of adjustment or in sound reproducing operation, that capacity will be within the limits which must necessarily be observed, with any given inductance and resistance of the circuit, to insure oscillation. In other words, the circuit of the condenser is always an oscillating circuit, but its free periodicity is varied by the varying capacity, and it is the variation of its intrinsic periodicity, more or less in synchronism with the periodicity of the oscillations impressed on that circuit, that varies the R. F. current flowing therein. Thus, as an illustration, suppose the constant oscillations are of 60 m. wave length. The intrinsic oscillations in the variable condenser circuit may then vary through a range either below 60 m. or above 60 m.

Any kind of record wherein the original sound is represented by elements having correspondingly varying capacity of di-electric strength may be used in my system. It is not necessary that a record containing silver or any other metal be used; in fact there are certain advantages in using records containing other substances. In using a silver-containing or similar record it is of course necessary that the successive images be large enough in proportion to the size of silver grains, or that the film be run fast enough, that variations in capacity due to the individual silver grains themselves shall cause vibrations that are beyond the limit of audibility. Other substances which may be used in records of a type suitable to my system may not have such limitations. For instance records may be made on film carrying bichromated gelatin images; and many other light sensitive substances will suggest themselves to those skilled in the art, as well as substances from which suitable records may be made without the aid of photography. Whatever those light sensitive substances are, or whatever may be the resultant development or transformation products which form the final record, and regardless of whether

the final record is visible or not, the varying amounts of development or other product in successive images will always introduce, at least to some degree, a varying factor of capacitance or of di-electric characteristic which will be effective in my system. Generally speaking, no two different substances have exactly the same di-electric or capacitance characteristic; and therefore any image substance—any substance different from the gelatin which it, in effect, displaces—will introduce the varying characteristics on which the operation of my system depends.

Likewise it is of no particular concern in my system as to just how the records are initially made, only provided that the successive images or image lines or areas of the record present the varying characteristics which I have herein set forth, and present them in such a way that they may be made use of to vary the effective capacity of a condenser assembly. Without attempting in the least to exhaust even illustratively the possible variations in types of records I have indicated diagrammatically in Figs. 3 and 4 the making of two other types of record.

For instance in Fig. 4 the elements of a cathode ray tube are diagrammed, the two electrodes being indicated at 35 and 36. The cathode ray passes through a slit 37 and plays upon and along the length of a luminiscent surface 38, creating a line of light which, under normal circumstances, is straight. By using two electromagnets 39 which are energized from the circuit 40, 41 carrying an audio frequency current, the line of light in the cathode ray tube may be fluctuated or bent away from its normal straight path. If a slit 42 is then placed so that in the normal ray position the slit appears to be full of light, then as the cathode ray is deviated the image viewed through the slit by lens 43 will appear as a wedge which may have a fixed base at one end of the slit, but is of varying length. Such single images are indicated at I in Fig. 4. The resultant composite or aggregate image produced on the moving film when the film is developed will be somewhat similar in appearance to that produced by the glow tube before described. Thus, as before, the outline 17^a through the tips of the successive images will represent the characteristics of sound, the lengths of the image will represent the amplitude of vibrations and the wavy outline will represent frequency and sound character.

In Fig. 5 I indicate the making of another form of record wherein only varying spacings between successive images and varying densities of those images are used. For instance a filament light with a filament 50 may have its image thrown upon the traveling film by a lens 51, a slit 52 being used if desired. The successive images 15^a on the film will be all of constant length but will vary in spacing and in density.

It will of course be understood that what I refer to as "images" are not in reality separate images, as if the film where being moved intermittently. The final composite image is actually made up of an infinite number of what may be called instant images.

I may also note that the showings of film images are here made in negative form, in illustrating both the production and reproduction of the film: The use of positives, or of duplicate negatives will, however, be well understood.

In order further to illustrate other typical possibilities of my system I refer now to Figs. 6, 7 and 8.

In Fig. 6 a film 12^a like that of Fig. 5 is illustrated wherein the record image 15^a is made up, in appearance, of a plurality of shaded lines. Instead of using the record to modify the di-electric element of the variable condenser, the record can be used in such a manner that its component images become one plate of the condenser. This would be especially true of a record of that type shown in Fig. 6 where a film has been run fast enough that the component images, so to speak, are spaced more or less widely from each other, so that, between successive image areas that have comparatively high capacitance characteristics, there are intervening parts of the record that have relatively high resistance. Using a record of such a type, for instance, a small brush, indicated diagrammatically at 50, may be placed in such a position that it will contact successively with each component image as the image comes opposite the condenser plate 20^a; so that, as each component image comes into opposing relation to the condenser plate, it is connected into the circuit 25—26 so that it becomes in effect a plate of the condenser. In this arrangement, as in all the other variations of my system, it is of course aimed to make the condenser action include, at any given instant, substantially the same image area as was originally produced on the record at any given instant. In the form of Fig. 1 this is accomplished by having the width of the plates 20 correspond to the width of the instant image; and in the form shown in Fig. 6 plate 20^a will also be made to correspond in width to that image width. Although in Fig. 6, using the illustrated type, or other types of records, the record may be charged to some extent along the film in both directions from the instant area which is in opposition to plate 20^a, those parts which are immediately opposite the plate 20^a will, at least in the main, predominantly or exclusively affect the condenser action; and, furthermore, the resistance of such a record in a longitudinal direction can be

made such that the oscillating current cannot pass along its length to any great extent.

The system of Fig. 6, other than explained above, may be the same as that of Fig. 1, the general action being the same.

In Fig. 7 a system of another different type is illustrated. Here the circuit 25^a—26^a is connected directly into the oscillating circuit O′ which feeds, through the coupled inductances L and L^1, into a detector and amplifying circuit which may be substantially the same as before described, but which is merely indicated in Fig. 7. In this case, however, instead of running the film between the two condenser plates 22, it is run past the edges of the plates so that, as the successive image areas cross the space between the plates, they vary the effective capacity of the condenser made up of those two plates. This variation may be looked at either as a variation in the effective di-electric between the two plates, or as a variation in a short-circuiting but high resistance between the two plates.

In Fig. 8 still another arrangement is illustrated. Here I show a film 12^b having two complete records 15^b and 15^c. Such a record, and its production and reproduction, are the subject-matter of my co-pending application S. N. 228,711, filed Oct. 26, 1927. I may here explain that such a double record may involve one record 15^b, the same as any of the records hereinbefore explained, and a corresponding complementary record 15^c. Such a record will have been made, for instance, by using two glow tube sets, such as shown in Fig. 3. One such set will be fed with one undulating current and the other with a complementary undulating current, so that the two records 15^b and 15^c will be complements of each other, their outlines being identical but one record having a maximum image opposite a minimum image in the other record. Using such a record, one common condenser plate 20^c may be located at one side of the film and a pair of shorter condenser plates 20^d and 20^e located oppositely, the film running between them and plate 20^c, so that condenser 20^c—20^d is affected by record 15^b and condenser 20^c—20^e is affected by record 15^c.

Such a record lends itself readily to a balanced arrangement of the two condensers in a bridge circuit wherein the condenser actions aid and augment each other. Such a circuiting is shown in Fig. 8 wherein plate 20^c is connected into the center of two coupled inductances L^a—L^a, these being connected at their outer sides through wires 25^c, 26^c to plates 20^d, 20^e, respectively. The circuit thus formed constitutes a part of the oscillating circuit O^2, with the individual condenser circuits in bridged balance. The remainder of the circuit, for rectification and amplification, may be as desired.

In such systems as I have described it is highly desirable, if not absolutely necessary, that the oscillation periodicity be as unvarying as possible. For this purpose crystal controls may be used in any of the arrangements I have described—their use is well known. I have illustrated them, for example, at C in Figs. 7 and 8.

I claim:

1. In a system of sound reproduction, the combination of a sound record wherein sound vibrations are represented by portions of the record having varying dielectric characteristics, said sound record comprising two complete complementary sound wave representations, an electrical circuit including an input inductive winding, and a condenser assembly of which said sound record forms a dielectric, said condenser assembly comprising, a pair of condenser plates, one positioned over each of said complementary sound wave representations, and a third plate positioned over both of said complementary sound wave representations, said first mentioned condenser plates being connected to opposite ends of the inductive winding, and said last mentioned condenser plate being connected to a mid-point of the inductive winding.

2. In a system of sound reproduction, the combination of a sound record wherein sound vibrations are represented by portions of the record having varying dielectric characteristics, said sound record comprising two complete complementary sound wave representations, an oscillating radio frequency circuit including an inductive winding and a condenser assembly of which said sound record forms a dielectric, said condenser assembly comprising, a pair of condenser plates, one positioned over each of said complementary sound wave representations, and a third plate positioned over both of said complementary sound wave representations, said first mentioned condenser plates being connected to opposite ends of the inductive winding, and said last mentioned condenser plate being connected to a mid-point of the inductive winding, and means for transforming the radio frequency current of said circuit into an audio frequency current and amplifying it.

In witness that I claim the foregoing I have hereunto subscribed my name.

ROY J. POMEROY.