Patented Sept. 6, 1949

2,481,247

UNITED STATES PATENT OFFICE

2,481,247

VISUAL REPRESENTATION OF COMPLEX WAVES

Lionel Schott, East Orange, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application October 10, 1946, Serial No. 702,379

9 Claims. (Cl. 179—1)

1

This invention relates to the analysis and visual representation of complex waves, and, more particularly, to the visual representation of speech sound waves and the like.

It has already been proposed to translate audio frequency complex waves, such as correspond to speech sounds, into visual patterns or spectrograms characteristic of or respective to particular speech sounds. Study of such visual patterns by an observer, for example, a deaf person, and mental association of the appropriate speech sounds therewith, furnishes the observer with a vocabulary or an alphabet of visual patterns. So equipped, the observer is enabled to comprehend the content of a phrase or sentence uttered by another, or himself, and that may be contemporaneously translated by suitable means into a complex electric wave and converted into a succession of visual patterns representatively corresponding to the speech sounds of the original.

An object of the invention is to provide improved method and means for visually representing a complex wave such as that of a speech sound.

A more specific object is to provide method and means for producing from message or signal waves, and more particularly speech sound waves, a contemporaneous visual representation thereof of such a character as to reveal relatively readily the message or signal content.

A feature of the present invention comprises displaying or visually representing a speech sound in the form of a pattern in which appropriate signals or indications corresponding to component frequency bands of the speech sound are displayed on a viewing area along respective angularly displaced lines of direction having a common origin or point of reference.

Another feature comprises visually representing a speech sound, and in which the outward extension or position of the indication along the respective line of direction is a measure of the energy content or intensity of the corresponding component frequency band.

In accordance with the present invention, the complex wave corresponding to a given or particular speech sound is divided into a plurality of discrete or component frequency bands each of which is assigned, for purposes of a visual representation, one of a plurality of angularly displaced positions or lines of direction having a common origin or reference point in a viewing area. These discrete bands are scanned successively and cyclically a number of times each second, and their energy contents or intensities

2

are translated into radial displacements of an energy ray or electron beam at the respective angles or along the respective lines of direction for the individual frequency bands, whereby, if the energy ray is directed against a luminescent or a fluorescent screen, a trace representative of the complex wave is produced thereon. In a particular embodiment, the complex wave is divided into a multiplicity of discrete or component frequency bands by a suitable band-pass filter network, and the alternating currents of the respective bands converted into direct current control signals. These signals are applied, through a commutative connector, successively and cyclically to the deflecting elements or plates of a cathode-ray tube or oscilloscope, to deflect the cathode ray or beam therein successively and cyclically at the angles assigned to the respective component frequency bands and to an extent or displacement radially determined by the energy content or intensity of the respective component frequency band.

A more complete understanding of the invention, and of its other objects and features, will be obtained from the detailed description that follows, taken in conjunction with the appended drawing, wherein:

Fig. 1 illustrates a system for practicing the invention; and

Fig. 2 is a fragmentary representation of a cathode ray tube.

The arrangement shown in the drawing for practicing the invention comprises a source 10 of complex electric wave, a plurality of band-pass filters BPF1, BPF2, etc.; a corresponding plurality of rectifying means or devices 11, 12 . . . 22; a visual indicator device CRT; and a commutative means or connector CM.

The source 10 may comprise a sound wave energy pick-up device or microphone, as indicated (source of microphone potential, and possible amplifying means being omitted for purposes of simplicity), or might consist of any appropriate source of complex electric wave input to the filters, for example, a phonographic or film record and pick-up, or a transmission line carrying the electric wave to be studied or read in accordance with the invention. The filters BPF1, BPF2, etc. are adapted to divide the band of frequencies embraced by the complex wave into a plurality of discrete or component frequency bands, or frequency subbands, of substantially equal band widths.

In the illustrative arrangement, twelve filters are provided and, if it is assumed that the comdegree position segments, resistances of R1, R2, R4 values are again employed, but the inner segment B3 receives the higher voltage for application to the deflecting plate 2, while the outer segment A3 receives the lower voltage for application to the deflecting plate 1. Similar considerations apply for the connections from the filters to the segments in the other three quadrants. When a positive potential is applied to one deflecting plate through a commutative segment, the opposite or associated deflecting plate is effectively connected at negative potential through the grounding brushes 20, 21. The distribution of the voltage output of the particular band-pass filter between the deflecting plates 1, 2 (for the filters BPF1, BPF2, BPF3), or the plates 2, 3 (for the filters BPF4, BPF5, BPF6), or the plates 3, 4 (for the filters BPF7, BPF8, BPF9), or the plates 4, 1 (for the filters BPF10, BPF11, BPF12), determines the angular deflection or line of direction of the oscilloscope energy ray or beam; and the intensity or magnitude of the voltage output of the particular band-pass filter determines the radial location or outward extension of the luminescent spot developed by the beam on the oscilloscope screen. Given a screen of appropriate retentivity of luminescence, and selection of appropriate rate of repeated sweeping or scanning of the filter outputs by the commutative means, a visual pattern characteristic of a specific complex wave may be obtained, or a succession of visual patterns be produced as the complex wave undergoes successively different specific frequency contents. If the energy contents of the successively swept or scanned component frequency bands are the same, the radial displacement of the cathode ray or electron beam will be the same and the pattern developed on the screen for the particular speech sound will be substantially symmetrical in outline. In general, however, the energy content for a particular speech sound varies in distinctive manner with frequency over the frequency band for such speech sound, and the radial displacement of the electron beam will be different for the successive component frequency bands, whereby the visual pattern for each speech sound will have a distinctive irregular outermost outline about the center of the viewing area on the screen, or, alternatively phrased, about the normal or idle position of the luminescent spot developed by the electron beam on the screen in the absence of speech sound input to the system. The input impedances to the deflecting plate circuits are preferably high relative to the values of resistances R1 . . . R5, so that no appreciable change in the voltages will occur when the oscilloscope plate circuits are connected across these output terminations of the filter circuits.

It is apparent that any number of segments and associated discrete or component band filters may be suitably arranged and operated in the manner described. In fact, a large number of discrete or component frequency bands might be used to increase the detail in the visual pattern. To the same end, the number of segments in the commutative means could be increased with respect to a given number of band-pass filter circuits. The twelve band-pass filter circuits, for example, might be arranged to operate twenty-four, thirty-six or forty-eight segments in the commutative connector, to provide corresponding numbers of equally angularly spaced radial lines and consequent smoother pattern outlines. The visual patterns so far described are in the nature of areas whose apparent boundaries are defined by the outer extremities of the radial lines, with the latter appearing to fill in or shade the areas. If it is desired that only the outline of the pattern area should be shown, that may be accomplished by filtering out the alternating components, first, in the energy supplied to the commutative means from the rectifier means, and then in the energy supplied to the cathode ray tube deflecting plates from the commutative means. It is to be understood that the length of the segments in the commutative means and the spacing between adjacent segments are not necessarily critical.

What is claimed is:

1. In combination with a receiver of complex waves, a multiplicity of frequency selective means for separating the received waves into a corresponding multiplicity of component frequency bands, an oscilloscope including means for producing an energy ray and two deflectors adapted to deflect the ray in respective different directions, and means including a commutative connector between said selective means and said deflectors for deflecting said ray in a multiplicity of different directions in cyclically repeated succession and, in each said direction, to an extent dependent on the intensity of the waves in a respectively corresponding component band.

2. In combination, a source of complex electric wave corresponding to a speech sound; frequency selective means for dividing the frequency content of said wave into a plurality of discrete frequency bands; means for deriving a plurality of direct currents representative of the energy contents of the respective frequency bands; visual indication means comprising an electron beam source, a luminescent screen against which the beam is directed, and deflecting elements to deflect the beam in accordance with control signals applied to said elements; and means for converting said currents successively and cyclically into control signals and for applying said control signals to said deflecting elements to deflect said beam in a plurality of different directions individual to the respective frequency bands, in cyclically repeated succession, and in each said direction, to an extent representative of the energy content of the respectively corresponding frequency band, to produce a visual pattern on said screen representative of said speech sound.

3. In combination with a source of complex waves; a multiplicity of frequency selective means for dividing waves from said source into a corresponding multiplicity of component frequency bands; electronic means including an electron beam and a luminescent viewing area against which the beam is directed; and means for deriving control signals individual to the respective component frequency bands, and for deflecting said beam in cyclical succession along a corresponding multiplicity of angularly displaced lines of direction having a common point of reference on said viewing area, and, in each direction, to an extent dependent on the intensity of the waves in a respectively corresponding component band, to produce a visual pattern on said viewing area representative of the complex waves.

4. In combination with means for converting speech sound waves into an audio frequency electric wave corresponding to said speech waves; means for dividing said electric wave into a plurality of component frequency bands; means for deriving successively and cyclically a corresponding plurality of control signals from said component bands; and means for converting said con-

trol signals into respective visual indications located on a corresponding plurality of angularly displaced lines of direction having a common point of reference and each respective to one of the compenent bands, to produce a visual pattern representative of the speech sound waves.

5. In combination with means for converting speech sound waves into an audio frequency electric wave corresponding to said speech waves; means for dividing said electric wave into a plurality of component frequency bands; means for deriving a plurality of control signals from said component bands; and means for converting said control signals into a plurality of visual indications located on a plurality of angularly disposed lines of direction having a common point of reference.

6. In combination with a source of complex electric wave, means for dividing said wave into a plurality of discrete frequency bands, means for deriving a plurality of control signals from said discrete bands, and means for converting said control signals into a plurality of simultaneous persistent visual indications located on a plurality of angularly related lines of direction having a common point of reference.

7. The method of producing a visual representation of a complex electric wave that comprises dividing said wave into a plurality of component frequency bands; deriving successively and cyclically a corresponding plurality of control signals from said frequency bands representative of the energy contents of the respective component bands; and converting said control signals into respective visual indications such that the visual indications are located at the outer portions of a plurality of angularly displaced lines of direction having a common point of reference and each respective to one of the component bands, and the relative distances of the indications from the point of reference being representative of the energy content of the respective component bands.

8. The method of producing a visual representation of a speech sound that comprises generating an electric wave corresponding to said speech sound in frequency and energy distribution content; dividing said wave into a plurality of component frequency bands; deriving successively and cyclically a plurality of control signals representative of the energy contents of the respective component bands; and converting said control signals into respective visual indications such that the visual indications are located at the outer portions of a plurality of angularly displaced lines of direction having a common point of reference and each respective to one of the component bands, and the relative distances of the indications from the point of reference being representative of the energy content of the respective component bands.

9. The method of producing a visual representation of a complex wave that comprises dividing said wave into a plurality of component frequency bands, deriving a plurality of control signals from said component bands, and converting said control signals into a plurality of visual indications on a plurality of angularly related lines of direction.

LIONEL SCHOTT.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,168,047	Skellett	Aug. 1, 1937
2,306,067	Lewis	Dec. 22, 1942
2,403,983	Koenig	July 16, 1946
2,403,985	Koenig	July 16, 1946
2,403,986	Lacy	July 16, 1946
2,403,997	Potter	July 16, 1946
2,423,103	Koechlin	July 1, 1947
2,429,229	Koenig	Oct. 21, 1947

Patented Sept. 6, 1949

2,481,278

UNITED STATES PATENT OFFICE

2,481,278

POLYOXYALKYLENE COMPOUNDS

Seaver Ames Ballard, Orinda, Rupert Clarke Morris, Berkeley, and John L. Van Winkle, San Lorenzo, Calif., assignors to Shell Development Company, San Francisco, Calif., a corporation of Delaware

No Drawing. Application August 31, 1946, Serial No. 694,417

4 Claims. (Cl. 260—615)

This invention relates to new and useful lubricating compositions and more particularly it relates to lubricants containing copolymers of trimethylene glycol or its derivatives with certain alkylene glycols, as well as the novel copolymers themselves.

It is well known that certain alkylene glycols having two hydroxyl radicals on adjacent carbon atoms may be polymerized to form viscous liquids or wax-like polymers useful to a certain extent for lubrication purposes. The products obtained have the general unit configuration

$$\left[-O-\overset{R_1}{\underset{R_3}{\overset{|}{\underset{|}{C}}}}-\overset{R_2}{\underset{R_4}{\overset{|}{\underset{|}{C}}}}-\right]_n$$

where n is an integer and R_1 through R_4 are hydrogens or organic radicals such as methyl, ethyl, isopropyl, etc. Alkylene oxides having the oxygen bridging two adjacent carbon atoms form similar polymers. Examples of alkylene oxides forming such polymers are ethylene oxide, propylene oxide, butylene oxide, etc. Glycols such as ethylene glycol polymers practically identical with those obtained from the alkylene oxides. As pointed out above, these monomers and polymers have at least one part of their configuration in common: the oxygen atoms as separated by only two carbon atoms, in each case giving, in the case of polyethylene oxide polymers of the configuration:

$$O-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-O-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-$$

Typical of lubricants comprising the higher alkylene oxides is polypropylene oxide, having the configuration

$$-O-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{CH_3}{C}}-O-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{CH_3}{C}}-$$

Polymers of butylene oxide and higher alkylene oxides differ in one respect from this latter configuration: the methyl substituent or one or more of the hydrogens is replaced by another hydrocarbon group (or other substituent) such as ethyl, propyl, etc. Hence, this whole series of polymers comprises chains of pairs of carbon atoms linked by oxygen atoms.

Polymers such as those of polypropylene oxide, may replace mineral oil lubricants for certain purposes, such as in hydraulic brake fluid compositions, etc. When used as engine lubricants it has two advantages over mineral oil lubricants, namely, leaving substantially no engine deposit, and having a low pour point.

However, the polyalkylene oxide and ethylene glycol polymers in general, and polypropylene oxide especially, have one serious drawback limiting their utility as general lubricants. This is the serious susceptibility of polymers consisting of units of the general configuration

$$-O-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-O-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-$$

to oxidation during normal use, such as in lubricating compositions. This instability towards oxygen causes considerable loss of the product during its use, since, instead of forming gums as in the case of mineral oils, polymers of this configuration decompose upon oxidation to form volatile materials which gradually escape from the lubrication system.

This tendency to oxidize and subsequently volatilize can be controlled to a limited extent by incorporation in the polymer of certain anti-oxidants. However, large percentages of these are required to maintain suitable stability. This causes undue lacquer formation on engine parts, apparently due to the stabilizer itself. Furthermore, even in the presence of considerable proportions of anti-oxidant materials, the polymers containing a predominating number of units having the

$$\left(-O-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\right)$$

configuration continue to oxidize and volatilize to an unsatisfactory extent.

It is an object of this invention to provide polymers which do not have this disadvantageous tendency to oxidize. It is another object of this invention to provide improved non-hydrocarbon lubricants. It is a further object of this invention to provide a process for copolymerizing trimenthylene glycol or its derivatives with alkylene glycols. It is still another object of this invention to provide copolymers having units of the general configuration

$$-O-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-$$

as well as units of the general configuration

$$-O-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-$$

It is a fifth object of this invention to provide stable polymeric materials useful as components in plastic compositions, lubricating compositions, rubber compositions, enamels, lacquers, etc. Other objects will be obvious from the following description of the present invention.

Now, in accordance with this invention it has been found that lubricants of excellent stability are formed by copolymerization of alkylene glycols containing the essential structure

$$H\left(O-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}\right)_s OH$$

where s is an integer, with trimethylene glycol or substituted trimethylene glycols of the general formula

$$H\left(O-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}\right)_t OH$$

where t is an integer. The polymers so formed consist essentially of chains having units of the general structure

$$\left[-\left(O-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}\right)_m\left(O-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}\right)_n\right]$$

wherein m and n are integers, the free carbon valences carrying hydrogens or organic substituents.

The glycols which are polymerized with the trimethylene glycols to form the lubricating compositions of the present invention are generally called alkylene glycols and may be monomeric glycols or a lower polymer thereof. These glycols have the general formula

$$H\left(O-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}\right)_s OH$$

wherein s is an integer and the free carbon valences are satisfied with hydrogens or organic radicals. Preferably s is a number from 1 to 10, and still more preferably from 1 to 4. While the carbon constituents may be hydrogen or any organic radical, it is preferred that each

$$-O-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}-$$

group have at least 2 hydrogen substituents the balance being aliphatic hydrocarbon radicals. When s is 1, such glycols include ethylene glycol, propylene glycol, butylene glycol, etc. When s is more than 1, the glycols include diethylene glycol, triethylene glycol, tetraethylene glycol, pentaethylene glycol, and the corresponding propylene, butylene, etc. glycols. When s is more than 1, mixed glycols useful in the present invention include ethylene propylene glycol, diethylene propylene glycol, diethylene dipropylene glycol, etc. as well as their substituted derivatives, and polymerizable homologs and analogs.

The glycols having the general formula

$$H\left(O-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}\right)_t OH$$

wherein t is an integer and the unsatisfied carbon valences carry hydrogen or organic substituents, are all derived theoretically from trimethylene glycol. Hence, glycols of the above configuration will be referred to herein as the trimethylene glycols. When t is 1, the trimethylene glycols have the general formula

$$HO-\left[\underset{R_2}{\overset{R_1}{\underset{|}{\overset{|}{C}}}}\right]_3-OH$$

The monomeric trimethylene glycols having the above general formula are derived from trimethylene glycol. Preferably, R_1 and R_2 are hydrogens. In such case, the polymers are formed from trimethylene glycol itself. If R_1 and/or R_2 are not hydrogens, they may be organic radicals such as alkyl, aralkyl, aryl, etc. Preferably if they are not hydrogens, they are hydrocarbon radicals, especially saturated lower hydrocarbon radicals, but may also be groups which contain olefinic or acetylenic portions. Typical of the trimethylene alkyl substituted glycols are the methylated trimethylene glycols, including 1-methylpropanediol-1,3; 2-methylpropanediol-1,3; 1,1-dimethylpropanediol-1,3; 1,2-dimethylpropanediol-1,3; 1,3-dimethylpropanediol-1,3; 2,2-dimethylpropanediol-1,3; 1,1,2-trimethylpropanediol-1,3; 1,1,3-trimethylpropanediol-1,3; 1,2,2-trimethylpropanediol-1,3; 1,2,3-trimethylpropanediol - 1,3; 1,1,2,2-tetramethylpropanediol-1,3; 1,1,3,3-tetramethylpropane-1,3; 1,2,3,3 - tetramethylpropanediol - 1,3; 1,1,2,2,3-pentamethylpropanediol - 1,3; 1,1,2,3,3 - pentamethylpropanediol-1,3; and hexamethylpropanediol-1,3.

In place of the methyl groups other alkyl groups may be utilized, such as ethyl, propyl, butyl, amyl, hexyl, heptyl, octyl, nonyl, decyl, etc., radicals, as well as their isomers. Preferably, when alkyl groups are the substituents R_1 and R_2, they have from 1 to 10 carbon atoms, and still more preferably from 1 to 5. It will be understood that R_1 and R_2 may be similar or dissimilar groups. Thus, when expanding the general formula given hereinbefore to its indicated number of carbon atoms, it then becomes

$$HO-\underset{R_6}{\overset{R_3}{\underset{|}{\overset{|}{C}}}}-\underset{R_7}{\overset{R_4}{\underset{|}{\overset{|}{C}}}}-\underset{R_8}{\overset{R_5}{\underset{|}{\overset{|}{C}}}}-OH$$

wherein R_3 through R_8 are either hydrogen atoms or similar or dissimilar organic radicals. Those derivatives of trimethylene glycol, other than trimethylene glycol itself, which give the most satisfactory copolymers for general use have either one or two of the R's as lower alkyl groups. Thus, 2-methylpropanediol-1,3 and 2,2-dimethylpropanediol-1,3 form excellent copolymers when treated according to the method of the present invention.

Other lower alkyl-substituted trimethylene glycols which polymerize readily are 1-methyl-2-ethylpropanediol-1,3; 2-methyl-2-ethylpropanediol-1,3; 1-methyl-3-ethylpropanediol - 1,3; 2-methyl-2-propylpropanediol-1,3; 1-methyl-2-isopropylpropanediol - 1,3; 2 - methyl-2-butylpropanediol-1,3; 2-methyl-3-butylpropanediol-1,3; and the homologs, analogs and derivatives of the same.

One or more of the substituents may be cycloaliphatic radicals. Thus, R_3 through R_8 may be such radicals as cyclohexyl, methylcyclohexyl, dimethylcyclohexyl, ethylcyclohexyl, etc. However, open-chain alkyl substituents give polymers having preferred properties.

The polymers have modified properties if the trimethylene glycol derivative contains other active groups or elements such as additional hydroxyls, carboxyls, carbonyls, halogens, sulfur, etc.

While the copolymers formed may be prepared from trimethylene glycol alone, or from a single trimethylene glycol derivative, copolymers having more than one variety of

$$-O-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}-$$

unit in addition to the

$$-O-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}-$$

units also may be prepared in order to vary the