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Modulated light communication system

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SUMMARY:

The invention will now be more fully described in connection with the accompanying drawings, so erably of the same cross-dimension as the crossin which Pig. 1 is a diagrammatic view of circuits and apparatus illustrating the ultrasonic lightmodulation method and system disclosed in the said application; Pig. 2 is an explanatory diagram; Pig. 3 is a reproduction of a photograph obtained by employing the light-modulation systern of Fig. 1, illustrating the effect produced upon a polarized beam or bundle of light in response to longitudinal compressional ultrasound waves imparted to a transparent solid piezoelectric. For the present, it will be assumed, medium through which the beam or bundle is in the further description, that it is not piezoelecpassed; Fig. 4 is a reproduction of a similar photograph illustrating the effect of transverse shearing ultrasound waves, the light beam, however, being of different polarization; Fig.

reproduction of a similar photograph illustrating the effect produced by employing a medium the transverse dimension of which is comparable to the wavelapgth of the ultrasound waves in the medium; Fig. 6 is a diagrammatic view, similar to Fig. 1, of a transmitting system constructed in accordance with a preferred embodiment of the present invention; Fig. 7 is a similar view of a receiving system; Fig. 8 is a view similar to Fig. 6 of a modified transmitting system; and Fig. 9 is of a modified receiving system.

As disclosed in the said application, a light source I, such, for example, as a mercury arc, is provided to produce high-intensity light rays.

The present invention is not however restricted to use with visible light. On the contrary, it has particular use in connection with infra-red rays.

An infra-red or even an ultra-violet filter 3 may, therefore, if desired, be employed. As explained in the said application, a filter 3, adapted to produce monochromatic visible light of any desired wavelength may also be employed, though the invention is operable with chromatic as well as monochromatic light.

The light waves are shown colMmated by a lens into a parallel beam or bundle of rays of crossdimension corresponding to the cross-dimension of the lens 5. The beam or bundle of light rays is such, for example, as a Nicol prism or a piece of polaroid, and thereafter to impinge upon a substantial area of the front surface 9 of a medium 13. The _ medium 13, of course, should be transparent to -5 the light rays employed, whether visible, infraof the light through the medium 13 between the front surface 9 and the preferably parallel rear surface 11. The transparent medium 13 is prefdimension of the light beam. Any other wellknown focusing system, such as a parabolic re-

Sector, may be used to direct the rays upon the medium 13. The rear surface II of the transparent medium 13 is shown separated from the front surface 9 by a thickness T. The transparent medium 13 may be constituted of a glass or non-crystalline fused quartz block, or any other transparent solid or liquid. It may or may not be trie but, on the contrary, that it is optically inactive, birefringent-free.and strain-free.

The medium 13 may be vibrated molecularly in is a any desired way. According to the illustrated embodiment of the invention, the vibrations are produced by means of an ultrasonic vibrator. For the production of high-frequency ultrasonic waves, the vibrator may be constituted of a piezoelectric crystal 15, as of quartz, but it may also be of the magnetostrictive, magnetomotive or of any other suitable type.

The quartz crystal IS may be vibrated at a predetermined frequency by connecting its two electrodes 17 and 19 to an oscillator 21. The period of vibration of the crystal IS may be relatively low, say, several hundred kilocycles, more or less, or as high as ten megacycles, more or less.

The ultrasonic vibrations of the quartz crystal adjacent, for example, the bottom edge of the medium, will therefore become transmitted or directed into the medium 13 toward the top edge.

The medium 13 may be held in place on the crystal 15 in any desired way, as by cement or even by a layer of oil to aid in this transmission or direction.

Let it be assumed, for the moment, that the quartz crystal vibrates along its thickness dimension, so that it alternately elongates and contracts vertically. If the height dimension of the medium 13 is equal to a whole multiple of the wavelength of the ultrasound waves in the medium, standing waves of ultrasonic frequency, as before stated, will theoretically be set up in the medium between its bottom and top edge surfaces. It is assumed that the medium 13 is of such a nature that, when it is vibrated molecularly to produce these theoretical standing waves therein, it becomes birefringent to the light passing therethrough along the direction of travel of the light through the medium which is substantially perpendicular to the direction of the ultrasound waves between the bottom and top edges.

As the cross-dimension of the parallel beam or bundle of the plane-polarized light rays impinging upon the front surface 9 of the medium corresponds to the cross-dimension of the lens 5, it is large compared to the dimension of the standing waves produced in the medium 13.

This is to be contrasted with the conditions obtaining in the prior-art diffraction methods and in the systems employing frequency sensitive crystalline media or shaped media, as discussed in the said copending application.

After passing through the medium 13, and vertical direction V, and the horizontal compoemerging from its rear surface 11, this large parallel beam or bundle of polarized light is shown in Pig. 1 focused by a lens 23 upon a screen 27.

The lens 23 and the screen 27, of course, may be replaced by some other optical system, such as an ocular, a camera, a photocell 22, or any other suitable system for receiving and indieating the beam of light from the rear surface 11 of the medium 13.

An analyzer is shown interposed between the lens 23 and the screen 27. It may be constituted of a piece of polarizing material oriented at right angles to the orientation of the polarizer 7. Under normal conditions, therefore, when the -circuit of the oscillator 21 is open, and the cry tal 15, therefore, is not vibrating, the polarized light passing through the medium 13 will be extinguished by the analyzer 25, to a degree depending only on the effectiveness of the polarizing and analyzing materials, with the result that the screen 27 will be dark.

The term "extinguished," of course, is used herein not only in its ordinary sense, as employed ordinarily in connection with visible light, but also more generally to denote also the more general phenomenon of blocking any of the light waves employed, whether or not visible.

When, however, the circuit of the oscillator is closed, to render it effective to vibrate the quartz crystal 15, standing waves of ultrasonic frequency, as already explained, will be set up in the medium 13, between its bottom and top surfaces. Alternate horizontally disposed equally spaced sectional portions of the medium 13 will become compressed and dilated by oppositely phased components of the vibration waves, in consequence. These compressed and dilated sectional portions will be separated by portions of the medium 13 where the standing sound waves in the medium 13 will produce nodes. Correspond -

ing changes in the refractive index will occur in the dilated and compressed portions of the medium 13, but the refractive index will remain unchanged at the nodes, since these nodal sections are not vibrating. The refractive-index changes will occur periodically, in synchronism with the vibrations of the medium.

It has already been stated that the invention is not restricted to use with monochromatic light.

In order to simplify the explanation, however, it will be assumed, for the present, that the light from the source I is actually monochromatic, of wavelength X.

Considering, for the moment, in the plane of the front surface 9 of the medium 13, any one of the horizontally disposed sectional portions of the medium 13, let it be assumed that a change dm has occurred in its refractive index along the vertical direction V, and that a corresponding change dm has occurred in its refractive index along the horizontal direction H, at right angles thereto. Let it further be assumed, for simplicity, that the plane of polarization of the light passing through the polarizer 7, upon reaching the plane of the front surface 9, is at degrees to the vertical, as indicated at P in Pig. 2.

This light, of amplitude Ko, may therefore be considered as having two equal in-phase polarized components of amplitude The vertical component Ev is polarized along the nent EH is polarized along the horizontal direction H. The instantaneous values of these components, at any time t, may be represented by the following equations:

Ev= coa " where a is the angular frequency of the light.

Since the change dm in the index of refraction a along the vertical direction V is different from the change Ant in the index of refraction along the horizontal direction H, these two polarized components will suffer different phase shifts durtheir passage through the medium 13. These Phase shifts m&y respectively be represented by an& lt;i & <t& gt;n=-d1 where is the ratio of the circumference to the diameter of a circle.

The .resultant of these two polarized components, upon emerging from the rear surface II of the medium 13, will therefore no longer, in general, be a plane-polarized wave, in general, ths wave will be elliptically polarized, and Its components will be respectively represented by j? -n t iAA & gt; f JAA i g g= cos (_ & lt;t& gt;!!& gt;

It is in this elliptlcally-polarized form that the components of the elliptically-polarized waves will pass through the crossed analyzer on their way to the screen 27.

This operation is therefore not the same as that occurring with optically active crystals or other crystalline substances as before described. The operation occurring with the optically active crystals depends upon rotating the plane of plane polarization. The operation occurring with permanently doubly refracting crystalline substances depends upon modifying the amount of double refraction. The operation of the present invention. on the other hand, depends upon depolarizing plane-polarized waves into elliptically polar-

Ized waves.

It has been explained that the analyzer may be so oriented that, when no ultrasonic vibrations whatever are propagated into the medium 13, the screen 27 is dark. When the oscillator 21 causes the crystal to set up standing ultrasonic waves in the medium 13, on the other hand, bright layers, striations, bands, regions or stripes 2 will appear on the screen 27. The layers, striations, bands, regions or stripes 4 between alternately disposed light layers 2 will remain dark.

With the analyzer adjusted in accordance with the above assumptions, so as to extinguish the light passing through the medium 13 at times when it is not vibrating, the dark stripes will correspond to the light passing through the nonvibrating or nodal portions of the medium 13.

The light stripes 2, on the other hand, will correspond to the successive portions of the light beam which have become elliptically polarized during passage through the corresponding compressed and dilated portions or sections of the medium 13.

It is not, of course, essential that the analyzer be so oriented as normally to extinguish the Mght passing through the medium 13. The analyzer may be so oriented that, under normal conditions, when the medium is not vibrating, the screen 27 shall just be illuminated. The compressed and dilated sections of the medium 13, produced in response to the vibration of the r& gt;r& gt; waves.

medium 13, may periodically produce elliptically polarized light, the major axis of which is normal to the orientation of the analyzer 25, so that most of the light passing through these sections, when they produce such elliptically polarized light, is extinguished. The light stripes 2 will then correspond to the nodes, and alternately disposed dark stripes 4 to the compressed and dilated sections of the medium 13, produced in response to the vibration of the medium 13.

In accordance with the present invention, tberefore, the analyzer may be adjusted initially so as normally either to extinguish the polarized light after its passage through the medium 13, or to permit the light to pass onto the screen 27. The analyzer may be adjusted to a degree such as initially to produce extinction and such that a slight change in the analyzing process in one direction, resulting from the action of the birefringent medium 13 to change the state of polarization of the light, will provide bands or sections 2 of illumination alternately th d3 bands or sections upon the screen 27.

may, on the other hand, be adjusted to a degree such as initially almost, but not quite, to extinguish the analyzed light on the screen 21 and such that an equal change in the analyzing process in the opposite direction, resuiting from the action of the birefringent medium on the light will produce dark bands or sections alternately with light sections 2 on the screen 27.

Since the light and dark layers 2 and 4 are produced periodically, in synchronism with the vibrations of the medium 13, the phenomenon, in reality, is produced stroboscopically. Because the frequency of the ultrasonic waves is many times greater than that of the flicker limit of the eve- however, the effect upon the observer will be the same as though the light layers 2 were produced with the aid of continuous light issuing fro the analyzer 25.

The difference (cJnidm) in the changes of the index of refraction along the vertical and horizontal directions is known as the birefringence of the medium. It is proportional to the total Phase shift suffered by the light in passing through the compressed and dilated sections of the medium 13. The intensity of illumination of the light stripes 2 is proportional to the square of the sine of half the phase shift suffered in Passing through the medium 13.

The stronger the vibrations of the sound waves, the greater will be the birefringence and the -& gt;3 greater the intensity of illumination of the light stripes 2. It is accordingly possible to regulate the light intensity in accordance with the signal produced by the vibrating quartz 15, as determined by the oscillations of the oscillator 21. A linear relationship has been found to exist between the light intensity and the signal amplifade produced by the quartz 15.

The operation above described has been upon the assumption that the height dimension of the medium 13 is equal to a whole multiple of the wavelength of the ultrasonic waves propagated through the medium between its bottom and top surfaces. This, however, was for explanatory purposes only. It has been found that, particularly at the higher frequencies, a medium of any arbitrary dimension may be employed, irrespective of whether or not it is a multiple of the wavelength, provided only that it is large with respect to the wavelength of the ultrasound has also been found that such a photoelastic-shutter system is not frequency-sensitive, and the dimensions need bear no specific relationship to the wavelength of the ultrasound waves.

Though the flat area of the crystal IS is shown, in Fig. 1, as substantially equal to the cross-sectional area of the medium 13 into which it propagates the ultrasound waves, this is not essential.

The medium 13 may have a cross-dimension o many times the area of the crystal 15, though the birefringence effect resulting from the ultrasound waves will then not be produced strongly throughout the whole medium. To produce the birefringence effect throughout such a large medium, and thereby to obtain an unlimited light area, even several square feet, a plurality of vibrators, as shown in Hg. 8, may be employed in contact with successive portions of the medium 13. A single large flat area crystal may also be used. No slits or stops are necessary.

The reproduction in Fig. 3 of an actual photograph obtained with the system of Fig. 1 will show, not merely the alternate horizontally-disposed light and dark layers or stripes 2 and 4, but rather a square-block-like appearance, produced by the addition of similar vertically disposed light and dark layers or stripes. These additional layers or stripes 2 and 4 are probably to be explained by the fact that, during the vibration, every elongation and contraction of the quartz crystal in the vertical direction is automatically accompanied by a contraction and an elongation, respectively, in the horizontal direction. These, of course, are also transmitted into the medium 13. In addition to the theoretical standing waves described above as set up in the medium 13 between the bottom and top surf aces in the vertical direction, therefore, standing waves appear to be set up also in the horizontal direction. Upon these standing waves at right angles to each other, moreover, there are doubtless superposed standing waves in still other directions, caused by reflection and other phenomena, the effects of which are not clearly shown in Fig.

3, though their existence appears to be betrayed in the photograph reproduced in Fig. 5. The resuit is not merely the before-described linear vibration of the medium 13, from top to bottom, but rather at least a two-dimensional vibration.

It is fortunate that, at least in the photograph reproduced in Fig. 3, the standing waves in the other directions do not interfere with the operation, according to the present invention, in the bottom-top direction. In this photograph, the standing waves at right angles to each other in the vertical and the horizontal directions are indicated as having very nearly equal effects upon the incident light. Since this incident light was described as polarized by the polarizer 7 at an angle of degrees to the vertical, as represented at P, these standing waves appear to produce similar effects upon this type of polarized light, even though the vibrations of the two types of vibrations are not precisely the same. This may explain the block-like appearance of Fig. 3.

With the dimensions and materials used, the changes of refractive index caused by the transverse shearing strain have been found to be smaller than those produced by the longitudinal compressional strain in the vertical direction.

The .

bright striations 6 of Fig. 4 are therefore not so intense as those in the case illustrated in Fig. 3.

Optimum results were found at substantially the degree angle of polarization.

Instead of 45-degree polarization, the light issuing from the polarizer 7 may be polarized at OJ ?J

any other desired angle. The effect of vertical polarization, for example, may be studied by considering the change of the refractive index resuiting from the shearing strain produced in the 6Q

medium 13 by its transverse vibrations as decomposed along two directions at right angles to each other along the plane of the surf ace 9. One of these may be an angle of degrees with respectto,flM& gt; vertical as& gt;may also be dicated at G5 P, Fig. 2, and the other may be indicated at P .

The components of the vertically-polarized waves along the 45-degree directions P and P, during their passage through the medium 13, will suffer different phase shifts, depending on the changes in the refractive index along the two directions P and P. The nature of the compressed and dilated sectional portions and the nodal portions of the medium 13 produced by the standing waves, of course, will by unchanged by this change in the angle of polarization of the light waves passing through the medium. For the reasons already given, therefore, owing to the biaxial birefringence thus produced, light layers will still appear on the screen 27 corresponding to the sheared sectional portions of the medium, and these will still be separated by dark layers corresponding to the nodal sectional portions of the medium 13.

These light layers and dark layers are respectively shown at 6 and 8 on actual photograph, reproduced in Hg. 4, taken when employing light of vertical polarization in the system of Fig. 1.

It makes a difference, therefore, not only theoretically, but also in practice, whether the polarization of the incident waves lies in one plane or another plane. This again demonstrates that the operation, according to the present invention, is not the same as that with an optically active crystal, the operation of which depends upon rotation of the plane of plane polarization, and not the depolarizing of the plane-polarized waves into elliptically polarized waves.

The distances between the centers of the successively disposed light or dark striations or layers are respectively equal to one-half the wavelength Xi of the longitudinal compressional vibrations and one-half the wavelength Xt of the transverse compressional vibrations propagated vertically and horizontally, respectively, in the medium 13. The values of these wavelengths obtained by measurement may be used directly to find Young s modulus and Poisson s ratio a.

As an example, ultrasound waves of a frequency /=10 megacycles were propagated, as illustrated in Fig. 1, into a sample 13 of plate glass 3.1 x 1.4 x 1.0 centimeters, having a density /& gt;=2.61. Upon measurement, the wavelength Xi of the longitudinal waves in the vertical direc-

Won was found to be 0.532 millimeter and the wavelength xt of the transverse waves was found to be 0.312 millimeter. Young s modulus e was tben calculated to be 7.65X1011 degrees/cm.2 from the formula Xf/V(l+& lt;r)(l2& lt;r Ttus value agrees with the values obtained for thesame sample 13 by diffraction methods.

6 ratl m of the longitudinal to the transverse wavelengths, efen to. bf m clof agreement with placements of the first difgCL35? ,produced b/.the transverse and i f" Poisso" s ratio then be obtataed from the equation _jm?l same sample (3 A very simple and almost instantaneous method , and means for todta th properties of the transparent medium are thus provided when the transverse dimension of the medium)3 was reduced to a value comparable with the transverse vibrational wavelength about 15 times the complicated effects shown in the before-mentioned Fig. 5 appeared.

Through still providing a large continuous area of ultrasonic stroboscopic light, Fig. 5 shows signs of frequency sensitiveness. In additinn tn th 2,623,16s light layers, intersecting patterns and scrolls SEU Jba ly reSHlting fr m

numerous oscillating at a high carrier frequency while in reflections within the medium.

Jtough corners or edges have been found to introduce no uncertainties in the operation.

The invention has heretofore been explained dimensioned medium to connection with birefringent-free and strainfree media 13. It is preferable to employ media of this character, and to adjust the analyzer so as to obtain complete extinction before the vibrations are initiated in the medium. Extremely intense stroboscopic-light layers have SJSJf,0bsred& gt;/r HXamPle& gt; mth n n produced elUpttcally-potettoed UgwSSJTSe crystalline fused-quartz media.

Chrystalhne substances haying permanent bi- 15 means than the screen refnngence, however, may also theoretically be employed. They also demonstrate light-intensity changes when subjected to ultrasonic waves, as described above. If an optically active medium 13, such as a piezo-electric crystal. is used, however.

then, in order to detect the effect of the hirefnngence on the light emerging from the face 11 of the medium, it is necessary to orient the analyzer 25 at right angles to the polarizer, and not so as to extinguish the light emerging from toe medium the plane of polarization of which has been rotated in passing through the medium.

It is then only that the birefringence effect, in addition to the optical activitj may theoretically be detected. In practice the much stronger effect of the change in optical activity produced by straining the medium may prevent the detection of the effects of b refnngence The use, in the system of Fig 1 of a strainfree optically-inactive, non-crystelline, isotropic medium 13 that is normaUy birefringent-free along the direction of travel of the light rays between the front surface 9 and the rear surface I. of the medium .3, therefore, not only makes possible the measurements above-described and the observance of the effects of ultrasonics m flashes from darkness to light of a high intensity.

the case of one crown-glass sample medium . from thp mnrinio nr.

of about the same dimensions as the sample previously discussed, the intensity change was found to be equal to one-tenth of the intensity of the mercury arc itself. Illumination of this order of intensity can be used, for example, to photo- Kn thT rpLS

graph scientific or other phenomena in motion at ultrasonic or other high frequencies. The frequency of the oscillator 21 needs merely to be adjusted until the moving object appears to stand still.

If a quarter-wave plate is inserted in front of each polarizing device 7 and 2 5, so that circularlypolarized, instead of plane-polarized, light is impinged upon the medium 13, and is analyzed after emerging therefrom, even stronger-intensity re- Rn suits occur. While some of the intensity resulting from the birefringence produced by the longitudinal waves is lost, this is apparently more than made up for by the light intensity resulting from the birefringence produced by the transverse waves. Waves having initially elliptical polarization may also be employed

Continous-wave signals may be transmitted by the system of Pig. 1 or of Fig. 6 in many ways.

as by interrupting the circuit of the escalator with a key. Modulated audio or video signals may be transmitted by modulating the carrier frequency of the oscillator 21. as by means of a modulator 20. Since the thin high-frequency crystal may be vibrated with wide side-bandwidths, the vibrations of the quartz crystal contact with the medium 13, are correspondingly modulated in accordance wi h tfa ?S3 oSeo g signal. The non-resonant 7elaS iSehas been found to respond sufficiently inrtantaneouS toTe mol mated ultrasonic carrier, propagated theremto from the crystal IS. to nroduce birefringencf S

response to the modulation signal M the receiving station, the lens 23 may therefore be caused to focus the toeWngencemedium 13 on to some other -light-receiving As illustrated1 in Fig 7, for example, a photocell 22 may be emDloved to receive elliptical "pSar Sda?ht In order" to detect the modulation , thTphotocell22 mav be connected to an audio or video amplifier 28 Crystalline media 13 may also be used for the photocell or photographic detection of this

light!

modulation transmission though with Umita tions of frequency sensitiveness and accom" panied by background noise or light The photocell 22 is itself sensitive to only a band of wavelengths. By designing ft s St it shall respond maximum Vffect to Ught having the wavelength of infrared or other mono chromatic rays. SseSlve and most noTseless operation may then be obtained with monochromatic light of such wavelenrth it has been found possible to trans mit as many as three different modulated signals through thl SyStem Of Kg. 6 simultaneous/with good re!

production, at the receiving end of three signals. The transmission may be effect/d hv feeding one or moS the modufatiS

to the same quartz or other ultraloniP

15. Such proSe tend?, LwS to the mechanical parts of the system channels may also be obtained by moSiSom S , 1?e,dlfferent ? %L lr f I fulgent frequency iSto iZf1 e?le to a bf v ""1? modulation- ere , J?nn when recelved ta ref vmE system of Rg. 9 which is operated 5m ir ma!??!r ? the Peration of the reving syste1 of Hg- 7- The PhotoceU may feed nea amplifiers, such as the amplifiers 28 and " .whac& will separate out and amplify the infm&ence of the different channels; for example, rre amP.Ufier J8 may separate out and amplify audio channel while the amplifier 28 amfles the video channel.

Audio frequencies ranging from cycles to 000 cycles have been used to modulate a ten-megacycle ultrasonic carrier with noiseless and distortionless results.

6 above-described system finds particular application also in television-projection systems such. for example, as the Scophony system, where liquid diffraction cells have heretofore Deea employed.

To control the volume and the performance of tnis light-modulation system, it is desirablefirst, properly to orient the plane of polarization of the polarizer; secondly to control the operation of the piezo-electric carrier on and off the resonant frequency of the piezo-electric crystal; thirdly, to position the medium 13 so L

to intercept more or less of the incident light; and fourthly, suitably to insert or remove a diaphragm, or to control the aperture of a diaphragm in the path of the light beam.

As a modification, if plane-polarized light is used, for example, the analyzer may be provided with suitable phase-shifting plates. The elliptically polarized waves emerging from the compressed and dilated regions of the medium will thus be properly analyzed, while permitting the plane-polarized light passing through the nodal-region portions of the medium to penetrate the analyzer 25. The use of a quarter-wave plate with the analyzer may be particularly desirable, for example, where the thickness T of the medium is such as to produce exactly a ninety-degree phase shift between the components V and H of the incident light, circularly polarizing the light emerging from the compressed and dilated regions.

The description above has been simplified on the assumption that monochromatic light is orations of the said predetermined wavelength used. Monochromatic light has its practical applications. The signalling system of Fig. 6, for example, could be used with infra-red or other invisible rays to provide added secrecy. The discussion above is equally applicable, however, to all wavelengths, even when employed simultaneously, that is, to chromatic light.

Further modifications will occur to persons skilled in the art, and all such are considered to fall within the spirit and scope of the invention as defined in the appended claims.

ENGLISH-CLAIMS:

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What is claimed is:

1. A communication system having, in combi- poination, a medium that is transparent to light nation, a medium that is transparent to light along a predetermined direction and that, when molecularly vibrated at a predetermined vibrational wavelength to produce standing waves therein between a pair of edges of the medium spaced from each other in a direction substantially perpendicular to the said predetermined direction a distance corresponding to several times the said wavelength, becomes birefringent to the light passing therethrough along the predetermined direction, means for passing through the medium along the predetermined direction a bundle of light of cross-dimension large compared to the wavelength of the standing waves, a polarizer for polarizing the light prior to its passage through the medium, an analyzer for analyzing the light after its passage through the medium, the analyzer being adjusted so that a change in the analyzing produced thereby in length at one of the said edges of the medium, one direction will provide extinction of the analyzed light and a substantially equal change in the analyzing produced thereby in the opposite direction will permit the passage of the analyzed light, means for producing molecular vibrations of the said predetermined wavelength at one of the said edges of the medium, means for directing the vibrations into the medium toward the other said edge of the medium in order that the vibrations may be reflected therefrom to set up the said standing waves, means for varying the molecular vibrations, and means for receiving the analyzed light to detect the variation.

2. Apparatus as set forth in claim 1 the vibrating means of which comprises means for propagating ultrasonic waves into the medium.

3. Apparatus as set forth in claim 1 the vibrating means of which comprises piezo-electric means.

4. Apparatus as set forth in claim 1 all of the dimensions of the medium of which are large determined direction, means for passing through compared to the wave-length of the standing waves.

5. A communication system having, in combination, a medium that is transparent to light along a predetermined direction and that, when molecularly vibrated at a predetermined vibrational wavelength to produce standing waves therein between a pair of edges of the medium spaced from each other in a direction substantially perpendicular to the said predetermined direction a distance corresponding to several times the said wavelength, becomes birefringent to the light passing therethrough along the predetermined direction, means for passing through the medium along the predetermined direction a bundle of light of cross-dimension large compared to the wavelength of the standing waves, a polarizer for polarizing the light prior to its passage through the medium, an analyzer for extinguishing the light after its passage through the medium, means for producing molecular viat one of the said edges of the medium, means for directing the vibrations into the medium toward the other said edge of the medium in order that the vibrations may be reflected therefrom to set up the said standing w ves, means for modulating the molecular vibrations, and means for receiving the analyzed light to detect the modulations.

6. Apparatus as set forth in claim 5 the vibrating means of which comprises means for propagating ultrasonic waves into the medium.

A communication system having, in comalong a predetermined direction and that, when molecularly vibrated at a predetermined vibrational wavelength to produce standing waves therein between a pair of edges of the medium spaced from each other in a direction substantially perpendicular to the said predetermined direction a distance corresponding to several times the said wavelength, becomes birefringent to the light passing therethrough along the predetermined direction, means for passing through the medium along the predetermined direction a bundle of light of cross-dimension large compared to the wavelength of the standing waves, a polarizer for polarizing the light prior to its Passage through the medium, an analyzer for extinguishing the light after its passage through the medium, means for producing molecular vibrations of the said predetermined wavemeans for directing the vibrations into the medium toward the other said edge of the medium m order that the vibrations may be reflected therefrom to set up the said standing waves.

means for modulating the molecular vibrations w11. a plurality of independent sigfKlsTnte-Sn or receiving the analyzed jighVand mea cobperative with the receiving meaniior separaHnif and amplifying the tadejoutetrt signals.

8. A conmflSifcatfon systemTiaving, in combination, a medium that is transparent to light along a predetermined direction and that, when moiecularly vibrated at a predetermined ultrasonic wavelength to produce standing waves therein between a pair of edges of the medium spaced from each other in a direction substantially perpendicular to the said predetermined direction a distance corresponding to several times the said wavelength, becomes birefringent to the light passing therethrough along the prethe medium along the predetermined direction a bundle of light of cross-dimension large compared to the wavelength of the standing waves, a polarizer for polarizing the light prior to its passage through the medium, an analyzer for 5 ing the amplitude of the said carrier-wave vifaraanalyzing the light after its passage through the medium, the analyzer being adjusted so that the analyzed light is almost but not quite extinguished, means for producing molecular vibrations of the said predetermined wavelength at one of the said edges of the medium, means for directing the vibrations into the medium toward the other said edge of the medium in order that the vibrations may be reflected therefrom to set up the said standing waves, means for modulating the molecular vibrations with an audio signal, and means for receiving the analyzed light to detect the signal.

9. A transmitter having, in combination, a medium that is transparent to light along a predetermlned direction and that, when molecularly vibrated at a predetermined vibrational wavelength to produce standing waves therein between a pair of edges of the medium spaced tfrom each other in a direction substantially perpendicular to the said predetermined direction a distance corresponding to several times the said wavelength, becomes birefringent to light passing therethrough along the predetermined direction, means for passing light through the medium along the predetermined direction, a polarizer for polarizing the light prior to its passage through the medium, means for producing molecular vibrations of the said predeelength at one of the said edges 35 through the medium for analyzing of the medium, means for directing the vibrations into the medium toward the other said edge of the medium in order that the vibrations may be reflected therefrom to set up the said standing waves, and means for modulating the 40 vibrations may be reflected, means for varying molecular vibrations of the medium.

10. A communication system having, in combination, a medium having front and rear surfaces and that is transparent to light along the direction between the front and rear surfaces, the medium being normally birefringent-free to light propagated along the said direction, means for passing a bundle of light toward a substantial area of the front surface, a polarizer interposed in the path of the light, an analyzer positioned in the path of the light emerging from the rear surface after its passage through the medium, means for producing ultrasonic vibrations at an edge of the medium of wavelength small compared with the distance between the said 55 straining the medium at equally spaced intervals edge and a second edge of the medium, means for directing the vibrations into the medium toward the said second edge in order that the vibrations may be reflected therefrom to set up standing waves that render the medium bire- 60 direction substantially parallel to the said surfringent to the light, means for modulating the molecular vibrations with an audio signal, and means positioned beyond the analyzer for rendering the signal detectable.

11. A communication system having, in com- es accordance with a signal, and means positioned bination, a medium having front and rear surfaces and that is transparent to light, means for passing a bundle of light toward a substantial area of the front surface, a plane polarizer interposed in the path of the light and oriented along a dimension of the medium, an analyzer positioned in the path of the light emerging from the rear surface after its passage through the medium and oriented at right angles to the polarizer, means for producing carrier-wave vibrations at an edge of the medium of wavelength small cornpared with the distance between the said edge and a second edge of the medium from which the vibrations may be reflected, means for modulattions, and means positioned beyond the analyzer for rendering the modulations detectable.

12. A communication system having, in combination, a medium having front and rear surfaces and that is transparent to light, means for passing a bundle of light toward a substantial area of the front surface, a plane polarizer interposed in the path of the light and oriented at forty-five degrees to a dimension of the medium.

an analyzer positioned in the path of the light emerging from the rear surface after its passage through the medium and oriented at right angles to the polarizer, means for producing carrierwave vibrations at an edge of the medium of wavelength small compared with the distance between the said edge and a second edge of the medium from which the vibrations may be reflected, means for modulating the amplitude of the said carrier-wave vibrations, and means positioned beyond the analyzer for rendering the modulations detectable.

13. A communication system having, in combination, a medium having front and rear surfaces and that is transparent to light, means for passing a bundle of light toward a substantial area of the front surface, means interposed in the path of the bundle of light for circularly polarizing the light, means positioned in the path of the light emerging from the rear surface after its passage the light, means for producing carrier-wave vibrations at an edge of the medium of wavelength small cornpared with the distance between the said edge and a second edge of the medium from which the a property of the wave, and means positioned beyond the analyzer for rendering the variation detectable.

14. A communication system having, in cornbination, a medium having substantially parallel front and rear surfaces, that is transparent to light, and that is of a predetermined refractive Index, means for passing a bundle of light toward a substantial area of the front surface, means for polarizing the light prior to its reaching the front surface, means oriented normally to the polarizing means for analyzing the light emerg-

Ing from the rear surface after its passage through the medium, means for periodically along a direction substantially parallel to the front and rear surfaces in order to alter the refractive index of the medium at the said intervals by a predetermined amount along one faces and by a different amount along a direction at an angle to the said one direction, thereby to render the medium periodically birefringent, means for varying the periodic birefringence in beyond the analyzing means for rendering the signal detectable.

15. Apparatus as set forth in claim 14 the medium of which is initially strain-free and the straining means of which comprises means for propagating ultrasound waves into the medium.

16. A communication system having, in cornbination, a medium having substantially parallel front and rear surfaces separated by a thickness T, that is transparent to light, and that is of refractive index n, means for passing a bundle of light having a predetermined wavelength 7 toward a substantial area of the front surface, means for plane-polarizing the light prior to its reaching the front surface, means for analyzing the light emerging from the rear surface after its passage through the medium in the direction of the thickness T, means for periodically straining the medium at equally spaced intervals along a direction substantially parallel to the front and rear surfaces in order to alter the refractive index of the medium at the said intervals by an amount dn\ along one direction at an angle to the plane of polarization of the light and by a different amaunt dm along a second direction at right angles to the said one direction, thereby to shift the phase of the component of the polarized light substantially parallei to the said one direction by an amount A&= -5& lt; Zi vibrated at vibrational wavelengths less than a and to shift the phase of the component of the polarized light substantially parallel to the said second direction by an amount A&=-dth ponding to several, times the said wavelength, whereby the light emerging from the rear surface of the medium becomes periodically converted into elliptically polarized light prior to its becoming analyzed by the analyzing means, and means for altering the periodic straining in accordance with a signal of lower periodicity.

17 ACommunicationt systemhaving in com- ef adjacenfc one of Wnation, a medium that is transparent to light along a predetermined direction and that, when molecularly vibrated at vibrat l wavelengths cular to the said predetermined direction a distance corresponding to several times the said wavelength, becomis birefringent to the light passing therethrough along the predetermined tion. a medium that is transparent to light along direction, means for passing through the medium along the predetermined direction a bundle of light of cross-dimension large compared to the dimension of the standing waves, a polarizer for polarizing the light prior to its passage through the medium, an analyzer for extinguishing the light after its passage through the medium, a plurality of means disposed adjacent one of the said edges of the medium for producing molecular ._ light passing therethrough along the predetervibrations of the said vibrational wavelengths and for directing the vibrations into the medium toward the said other edge of the medium

in order that the vibrations may be reflected therefrom to set up the said standing waves, means connected to the vibrating means for modulating the molecular vibrations, and means for receiving the analyzed light to detect the modulations.

18. A communication system having, in com- medium, plane-polarizing means disposed to pobination, a medium that is transparent to light 6- larize the successive beam portions prior to their along a predetermined direction and that, when molecularly vibrated at vibrational wavelengths less than a predetermined vibrational wavelength to produce standing waves therein between a pair of edges of the medium spaced from - the vibrations into the medium toward the other each other in a direction substantially perpendicular to the said predetermined direction a distance corresponding to several times the said wavelength, becomes birefringent to the light passing therethrough along the predetermined direction, means for passing through the medium along the predetermined direction a bundle of light of cross-dimension large compared to the dimension of the standing waves, a polarizer for polarizing the light prior to its passage through the medium, an analyzer for extinguishing the light after its passage through the medium, a plurality of piezo-electric crystals disposed adjacent one of the said edges of the medium for producing molecular vibrations of the said vibrational wavelengths and for directing the viorations into the medium toward the said other edge of the medium in order that the vibrations may be reflected therefrom to set up the said standing waves, means connected to the piezoelectric crystals for modulating the molecular vibrations, and means tor receiving the analyzed light to detect the modulations.

19. A transmitter having, in combination, a medium that is transparent to light along a predetermined direction and that, wnen molecularly predetermined vibrational wavelength to produce standing waves therein between a pair of edges of tne medium spaced from each other in a Direction substantially prependicular to the said predetermined direction a distance corresbecomes birefringent to light passing therethrough along pre(ietermined direction, means for passing through the medium along tne preaetcimlned oirection, a polarizer for polarizing mht prior to its passage through the medium, a plurality of means dismedium f producing molecular vibrations of the id TibrBttonal lengths and for directtag toe vibrations mto toe medium toward the the. """f i "Z

mo c fe medium.

H 20- A transmitting system having in combinaa predetermined direction and that when molecularly vibrated at a predetermined vibrational wavelength to produce standing waves therein between a pair of edges of the medium 6P& ced from each other in a direction substantiaUy perpendicular to the said predetermined direction a distance corresponding to several times the said wavelength, becomes birefringent to the mined direction, means for passing through a plurality of successive portions of the medium disposed between the said edges, each of width substantially equal to the half-wavelength of the standing waves, along the predetermined direction, a beam of light having a plurality of successive portions corresponding to the plurality of successive half-wavelength portions of the passage through the corresponding medium portions, means for producing molecular vibrations of the said predetermined wavelength at one of the said edges of the medium, means for directing said edge of the medium in order that the vibrations may be reflected therefrom to set up the said standing waves, thereby rendering the successive medium portions birefringent in antiphase in response to the resulting standing waves, and means for modifying the vibrations in accordance with a signal.

21. A transmitting system having, in combination, a medium that is transparent to light along a predetermined direction and that, when molecularly vibrated at a predetermined ultrasonic vibrational wavelength to produce standing waves therein between a pair of edges of tbe medium spaced from each other in a direction substantially perpendicular to the said predetermined direction a distance corresponding to several times the said wavelength, becomes birefringent to the light passing therethrough along the predetermined direction, means for passing through a plurality of successive portions of the medium disposed between the said edges, each of width substantially equal to the halfwavelength of the standing waves, along the predetermined direction, a beam of light having a plurality of successive portions corresponding to the plurality of successive half-wavelength portions of the medium, plane-polarizing means disposed to polarize the successive beam portions prior to their passage through the corresponding medium portions, means for

producing molecular vibrations of the said predetermined wavelength at one of the said edges of the medium, means for directing the vibrations into the medium toward the other said edge of the medium in order that the vibrations may be reflected therefrom to set up the said standing waves, thereby rendering the successive medium portions birefringent in anti-phase in response to the resulting standing waves, and mean for modifying the vibrations in accordance with a signal of greater wavelength.

22. A transmitting system having, in combination, a medium that is transparent to light along a predetermined direction and that, when molecularly vibrated at a predetermined vibrational wavelength to produce standing waves therein between a pair of edges of the medium spaced from each other in a direction substantially perpendicular to the said predetermined direction a distance corresponding to several times the said wavelength becomes birefringent to the light passing therethrough along the predetermined direction, means for passing through a plurality of successive portions of the medium disposed between the said edges, each of width substantially equal to the half-wavelength of the standing waves, along the predetermined direction, a beam of light having a plurality of successive portions corresponding to the plurality of suecessive half-wavelength portions of the medium, plane-polarizing means disposed to polarize the successive beam portions prior to their passage through the corresponding medium portions at forty-five degrees with respect to the direction of propagation of the standing waves, means for no successive medium portions birefringent in antiproducing molecular vibrations of the said predetermined wavelength at one of the said edges of the medium, means for directing the vibrations into the medium toward the other said edge of the medium in order that the vibrations may be reflected therefrom to set up the said standing waves, thereby rendering the successive medium portions birefringent in anti-phase in response to the resulting standing waves, and means for modifying the vibrations in accordance with a signal.

23. A transmitting system having, in combination, a medium that is transparent to light along a predetermined direction and that, when molecularly vibrated at a predetermined vibrational wavelength to produce standing waves therein between a pair of edges of the medium spaced from each other in a direction substantially perpendicular to the said predetermined direction distance corresponding to several times the said wavelength, becomes birefringent to the light passing therethrough along the predetermined direction, means for passing through a plurality of successive portions of the medium disposed between the said edges, each of width substantially equal to the half-wavelength of the standing waves, along the predetermined direction, a beam of light having a plurality of successive portions corresponding to the plurality of suecessive half-wavelengh portions of the medium, plane-polarizing means disposed to polarize the successive beam portions prior to their passage through the corresponding medium portions in a plane parallel to the said predetermined direction, means for producing molecular vibrations of the said predetermined wavelength at one of the said edges of the medium, means for directing the vibrations into the medium toward the other said edge of the medium in order that the vibrations may be reflected therefrom to set up the said standing waves, thereby rendering the successive medium portions birefringent in antiphase in response to the resulting standing waves, and means for modifying the vibrations in accordance with a signal 24. A transmitting system having, in combination, a medium that is transparent to light along a predetermined direction and that, when molecularly vibrated at a predetermined vibrational wavelength to produce standing waves therein between a pair of edges of the medium spaced from each other in a direction substantially perpendicular to the said predetermined direction a distance corresponding to several times the said wavelength, becomes birefringent to the light passing therethrough along the predetermined direction, means for passing through a plurality of successive portions of the medium disposed between the said edges, each of width substantially equal to the half-wavelength of the standing waves, along the predetermined direction, a beam of light having a plurality of successive portions corresponding to the plurality of successive half-wavelength portions of the medium, circular-polarizing means disposed to polarize the successive beam portions prior to their pass?e through the corresponding medium portions, means for producing molecular vibrations f the said predetermined wavelength at one of the said edges of the medium, means for directtog the vibrations into the medium toward the other said edge of the medium in order that the vibrations may be reflected therefrom to set up the said standing waves, thereby rendering the phase in response to the resulting standing waves, A means for modifying the vibrations in accordance with a signal 25. A communication system having, to combination, a medium that is transparent to light along a predetermined direction and that, when molecularly vibrated at a predetermined ultrasonic carrier vibrational

wavelength to produce standing waves therein between a pair of edges f the medium spaced from each other in a direction substantially perpendicular to the said predetermined direction a distance corresponding to several times the said wavelength, becomes birefringent to the light passing therethrough along the predetermined direction, means for passing through a plurality of successive portions of the medium disposed between the said edges, each of width substantially equal to the halfwavelength of the standing waves, along the predetermined direction, a beam of light having a plurality of successive portions correspondnig to the plurality of successive half-wavelength portions of the medium, plane-polarizing means disposed to polarize the successive beam portions prior to their passage through the corresponding 10 1,694,661 medium portions, means for producing molecular vibrations of the said predetermined wavelength at one of the said edges of the medium, means for directing the vibrations into the medium toward the other said edge of the medium in order IS 1,954,947 that the vibrations may be reflected therefrom to set up the said standing waves, thereby rendering the successive medium portions birefringent in anti-phase, means for modulating the amplitude of the carrier-wave vibrations in accordance with 20 2,234,329 a signal of greater wavelength, means for receiving the light passed through the medium, means for converting the received light into planepolarized light, and means for detecting the modulation of greater wavelength upon the ultrasonic 25 NuSe0r,0 carrier wavelength as variations in the converted light to reproduce the signal of greater wavelength.

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