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UNITED STATES PATENT AND TRADEMARK OFFICE GRANTED PATENT

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Sound ranging system

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SUMMARY:

The present invention relates ta electric systems, and more particularly to receiving systems using, sound waves as the agency of communication. The, term "sound" will be employed .hereinafter,, in the specification and the .claims, to include not only the audible part of the sound spectrum, but also, and ...more particularly, the. ultrasonic spectrum, and to include .also all kinds of elastic vibrations.

An object of the invention is-to provide.a new and. improved sound-receiving system.

Another object is to provide a novel combined sound-and-television system.

Another object of the. present invention is to provide a new sound-locator system for both detecting the presence of a body and producing a visible likeness thereof.

A further object is to provide a, new rangefinder.

Other and further objects will be explained hereinafter and will be more particularly pointed out in the appended claims.

The invention will now be more fully explained in connection with the accompanying drawing, the single, figure of which is a diagrammatic view of circuits and apparatus arranged and constructed in accordance with a preferred embodiment thereof.

A directive ultrasonic transmitter is shown comprising ultrasonic oscillator for exciting a piezo-electric crystal 10! and an auxiliary reflector ift3::for reflecting the energy emitted by" the piezo-electric crystal 10! upon a parabolic sound reflector !. Ultrasonic waves are thus propagated toward an object 3, illustrated as an underwater submarine. The sound waves are reflected and scattered from the surface of the object 3 toward a sound-receiving station. The invention is operable also with objects 3 that emit, as well as reflect or scatter, sound waves.

At the receiving station, the sound waves :thus reflected and scattered from the-object 3 may-be focused, converged or directed by a sound lens upon a bank or array 26, comprising a plurality of sound-receiving pick-up unit elements, vibratory tin-; response to .the soundr-energy impinging thereon. The sound lens 5 may be replaced: by an-jc.r other type of well-known .Jens, mirror or other directive system for focusingthe soundi waves scattered-and-reflected from the: object on the bank or array 26. of pick-up elements. The sound lens may, for example, be constituted of:a-,-collodion balloon filled with carbon dioxide or sulphur dioxide; or any other-substance for refracting, the -sound waves, The vibratile--pick-up elements of the bank..of array 26-are illustratively shown as,piezo-eleetricT. crystal-,:receiver elements embedded in the insu-r lating,-face 7 of a .-cathode-.ray-oscilloscoper-like member-9. They may,, for example, be constituted of Rochelle salt, di-hydrogen potassium-phosphate,; or any. othersuitable substance, ineluding-quartz. The front surf ace of each crystal-., element projects forward beyond-the face 7 of, -

the member r9, in the direction of the incoming-, sound-waves, but the-rear surface of each crystalelement is disposed within the cathode-ray-tube -

member 9.

The-crystal :pick-up::Units are-shown all elec- -

trically.poled inthe-same, manner and arranged;, in the form of rows and columns, .to the-proximity of the focal: plane .-of the lens. 5. The first, or: uppermost row of-the-, bank is illustrated as comprising the-groupjOf crystals-25,-r 23, 27, 21, 19, 17, !5, 13 and 11,: shown as equally spaced horizontally; The-second;.row from the top is shown constituted of a group of-similarly disposed crystals, respectively .-disposed directly: below the corresponding , crystals of the fli-jf row; several; of:; these: are: illustrated-at 29, 31 and 33. The-thirdt or next-lower row is similarly constituted, several of:.the.crystals .beingillustrated at and 37. Though .only, a; smaU.number of pick-up units is shown in each row,, and though only; three .rows.-.

are shown, this:is: merely, for illustrative purposes;.

in order not; to.confuse, the.disclosure;will beunderstood that, .in practice a..large.number of .

pick-up, units, will be employed: in .each row.

The;crystal -elements -25,529,; SS.ietc,, .are shdwnequally spaced vertically in-the first.or right-hand column. The .crystal;.;, elements::. 2 3,.-. 31;, 31, etc;, are disposed imthe seeond.column from the right. . The crystal .elements 21,i 33,:.etc.,, are: disposed in[& gt; the.-third .column, .fromr.the;: right,. and. so on::-...

There may,: or may. not.abe as many.columns:-as:.:. there are pick-up, units.ln...each row. Thougheach .column is shown-as comprising :only a-few:pick-up;units, .this, is-.again,.in order not to complicate the drawing.

The. pick-up: units, wilt: of.Icourse,.-,all,receiver: the reflected or scattered sound waves through the..lense 5 simultaneously. There will be fo-. cused on the front surfaceeach pick-up unit, a soundrwave intensity corresponding to-the intensity of the sound energy reflected or scattered from a corresponding component part, portion or. area of-the

object 3. Each pick-up unit will vibrate individually and separately in response to the sound waves impinged upon it. Electricwave energy, alternating-current voltages will thus be translated, produced or generated across the pick-up elements corresponding to the different field strengths of sound-wave energy thus received toy them. Since the piezo-electric effect is linear, these voltages will be proportional to the intensity of the sound-wave energy reflected or scattered or otherwise emanating from the various component portions of the object 3 and converged upon the array 26 of pick-up elements by the lens 5. The sound lens 5 or its equivalent will thus focus upon the array 26 the sound waves reflected or scattered from the various component portions of the object 3 in various energy strengths dependent on the reflecting properties of the component parts of the object 3, thus to produce a faithful sound image of this distribution of the sound waves in approximately the focal plane of the lens 5. The same result may be attained, as first pointed out by Lord Rayleigh, with the aid of a circular disc (not shown); go the sound waves from the object will become diffracted about the periphery of the disc to produce a similar sound image of the object 3. It has heretofore been .proposed to convert a soundenergy picture of this character into a visiblepicture likeness 123 of the object 3 upon the fluorescent viewing screen of a display cathode-ray oscilloscope tube 90. The tube 90, as well as the cathode-ray-oscilloscope-like member 9, is shown operating on the electrostatic principle, but, of course, a magnetic deflector, or a combination of magnetic and electrostatic forces, may equally well be employed in both the tube and the tube 9. Improved results may be obtained, however, in accordance with a feature of the present invention, with the aid of a load circuit in which may appear the totality or resultant of the voltages produced by all the soundwave receiving elements in response to the impingement of sound waves thereupon. This re4(j sultant voltage may then be diminished by successive quantities dependent upon the soundwave energy impinged upon the successively disposed sound-wave receiving elements, thereby to effect a scan of the distribution of sound waves impinged upon the elements.

The crystals II, 13, 15, etc. may be held in metallic crystal holders. The crystal II, for example, is illustrated as disposed between a pair of metal electrodes 41 and 51, and the crystal 13, between a pair of metal electrodes and 53. Adjacently disposed electrodes of adjacently disposed crystals are shown electrically connected together. The electrode 51 of the crystal II, for example, is shown electrically connected to the adjacently disposed electrode of the adjacently disposed crystal 13. The terminal electrode of the end crystal of each row, moreover, is shown electrically connected, as at 28 and 32, to the terminal electrode of the corresponding crystal of the next row. The crystals are thus all connected together in series relation with a source of energy, shown as a battery 2, one of the functions of which is to sensitize the vibratory response of the crystals, and a load impedance 4.

There will thus be produced across the load impedance & lt;3 a voltage dependent upon the sum of the alternating-current voltages produced across the individual crystals by the incident sound waves and the direct-current-biasing voltage of the battery 2. Provision is made, however, for short-circuiting successively disposed crystals, thus to develop or produce successively across the impedance 4 fluctuating current or voltage signals or indications corresponding to the 74 voltage drops across the successively disposed crystals and, therefore, to the corresponding strengths of sound-wave energy received by the crystals.

According to a further feature of the present invention, this short-circuiting or scanning process is effected with the aid of a scanning electron stream in the cathode-ray-oscilloscope-like member 9, which is shown provided with a vacuum-tube/ electron gun comprising a cathode 6, a control-grid electrode 8 and an anode 10. This obviates the necessity for mechanically moving parts or other complex scanning mechanisms and permits the use of common scanningvoltage ecircuits for effecting both the scan of the sound-wave receiving elements and the scan of the electron stream of the display cathode-ray tube, as hereinafter explained. Electrons emitted from the cathode 6 will become accelerated, in response to proper stimulation of the grid 8, so as to pass by the grid 8 to the anode of the member 9. The electrons will continue to travel in a stream from.the anode 10, between a pair of vertically disposed deflector plates 16 and 18, of which the plate 18 is shown grounded, and between a pair of horizontally disposed deflector plates 12 and 14, of which the plate 14 is shown grounded, to impinge finally on the disc 7 of the member 9. A horizontal-sweep-time base, applied to the vertically disposed deflector plates and 18, will cause the electron stream from the cathode 6 to become deflected horizontally as many times as there are rows of pick-up elements. After each horizontal sweep or scan of the cathode-ray or oscilloscope-like member 9 has been completed, a successively larger voltage will be applied to

the horizontally disposed deflector plates 1.2 and Ifl of the member 9, by a vertical- :;s weep-time base causing the electron stream to become deflected vertically, and causing each of the horizontal sweeps to appear at successively lower levels on the face 7 corresponding to successively lower vertically disposed levels of the -rows of elements. The rows of crystals may be positioned along the successive paths of the electron stream, as the electron stream successively sweeps or scans the successive rows of the array on the disc 7. After the last such horizontal sweep, the horizontally disposed plates of the member 9 will become restored to their starting voltage. The next horizontal sweep, therefore, will start again at the first or top row. Sweep or scan-voltage generators and 22 may be employed to produce the horizontal-time-base sweep and the vertical sweep, according to conventional and well-known television techniques.

The distance or spacing between the electrodes of each crystal, such as the electrodes 4! and of the crystal 11, may be made of value necessary to give a desired capacitance to provide a circuit resonant to the frequency of the received sound waves, thereby further to enhance the mechanical vibrations of the crystals, and the anode may be adjusted so that the distance between the pair of electrodes of each crystal shall be equal to the width of the electron stream. The electron stream will thus become enabled to fill the gap between the electrodes of each crystal, thereby discharging the capacity between these electrodes.

As the electron stream produced from the cathode 6, in response to appropriate horizontal sweep-time-base voltages applied to the vertically disposed deflector plates 16 and 18 of the cathoderay-like member 9, travels across between the Crystalelectrodes, the voltages-built up across the crystal electrodes of ;each crystal -become successively discharged-to effect the short-circuiting of the crystals,-thus affording successive indications of the intensity of the sound energy impinged upon :the particular crystals. These indications will be made evident across -the impedance -4, and may be amplified in a preferably linear amplifier 24. This amplifier 24 is operated at a high point on its characteristic curve by virtue of the bias battery 2 in series with the small alternating voltages from the crystals across the input of the amplifier. The positive swings of the alternating voltages from the crystals drive the tube 24 into the saturation region-, wMle-the negative swings are - amplified on the linear characteristic, thus producingpositive -pulses at the plate or anode of the amplifier 24. Operating, in this manner, as an overdriven amplifier, it serves, therefore, as a rectifier.

Uponthe successive short-circuiting of each crystal-condenser element by the electron stream-, as discussed above, the alternating voltage across the impedance 4 is diminished by the small voltage from the particular crystal element representative ofLthe intensity of the sound wave impinged on that element. The amplified positive pulses occurring in the output of the amplifier 24, during the scanning of a crystal, therefore, will have a peak amplitude that is less than before by an amount equal to the amplification of the tube multiplied by the voltage appearing across the particular crystal element. The output of the amplifier 24 will thus obviously vary, at successive instants, in accordance with the discharge or short-circuiting of the successive crystals, which discharge, as before stated, is a measure of the. strength of the sound energy received by the corresponding pick-up elements.

Means is provided, controlled by the discharge or short-circuiting of the crystal electrodes, for producing, upon the screen .30 of the display oscilloscope 98, images !23 corresponding to the sound energy received by the corresponding pickup elements. Successively disposed parts, portions, regions or areas of the screen 30, that correspond .to the similarly disposed pick-up .elements, are energized by an electron stream in the oscilloscope 9B to illuminate them. This electron stream is synchronized to travel with the electron stream of the cathode-ray-like member 9. The horizontal sweep circuit is shown connected to.the horizontal-deflector plate i IB of the oscilloscope 90, and to the horizontal deflector plate 16 of the oscilloscope-like member 9. The vertical-sweep circuit 22 is shown connected to the vertical-deflector plate-112.-,of the oscilloscope SO and to the vertical-deflector plate 12 of the oscilloscopeTlike member 9. The other horizontal-deflector plate .118 and the other .vertical-deflector plate-., 114 of the . oscilloscope are shown grounded.

The .amplifier 24 is shown connected by a conductor 38 to the control-grid electrode 80, and by a conductor 34 to .the cathode SO of the cathode-ray oscilloscope 90. Electrons emitted from the cathode will become enabled, as hereinafter explained; in response .to the action of the amplifier 24, to pass by the grid 80, to .the .anode (of the oscilloscope tube 90.: The electrons will continue to travel in. a stream from .the anode (OQfibetween the

pateof.vertically disposed oscilloscope deflector plates-.ilS and 118,; and between the.i.pair. of: horizontaly..disposed-oscilloscope-d&rj flector :plates 112 and 114, to impinge finally diLthe fluorescent viewing screen of the oscilloscope SO. As previously described in connection with the oscilloscope-like member 9, the horizontal-sweep-time base, applied to the vertically disposeddeflector plates 116 and i 18, will cause the electron stream from the cathode to become deflected horizontally, and the vertical-sweeptime base, applied to the horizontally disposed deflector plates 112 and 114, will cause the electron stream to become defiected vertically.

Since the cathode-ray tubes 9 and are subjected to the same scanning voltages, the electron stream in the tube will impinge on the fluorescent screen SO in synchronism with the electron stream, impinging on the crystals on the face 7 of the oscilloscope-like member 9 during the voltage-discharging or scanning process. The signals amplified by the amplifier 25, and fed between the cathode SO and the control electrode 80, will produce intensity modulation of the beam impinging on the screen 30. Prior to the discharging process, the positive swings or pulse outputs of the amplifier 24 would make the cathode SO periodically positive with respect to the grid 8E. In conjunction with the bias of a battery disposed between the cathode and the grid 09, this would permit the passage of but few of the electrons of the electron stream beyond the grid 80. Since, during the discharge of a crystal element, however, the positive swings or pulses in the output of the amplifier 24 are of a peak amplitude less than the original pulses by an amount proportional to the voltage produced by the sound waves across the particular crystal element, the cathode BG is periodically driven less positive with respect to the grid 80. A larger quantity of electrons are thus permitted to travel periodically past the anode 100, during the train of pulses produced by a crystal-condenser discharge, to impinge finally on the fluorescent screen -30. The quantity of electrons that reach the screen to produce intensity modulation during the scanning of a particular crystal, therefore, depends on the decrease in the output of the amplifier 24, and this, in turn, depends upon the voltage produced across the crystal by the sound-wave intensity impinged thereon. The electromagnetic illumination resulting from the intensity of modulation on the screen will be such that the intensity of illumination of parts of the screen corresponding to parts of the crystal bank 2S will correspond to the soundwave image on the rows and columns of the bank 28; this sound-wave image, in turn, corresponding to correspondingly disposed parts of the object 3.

To each row of crystals, therefore, there corresponds, on the face 7 of the oscilloscope-like member .8, a horizontal electron stream that discharges the crystals of that row. To the sound distribution on each row of crystals, moreover, there corresponds, on the oscilloscope screen 39, a horizontal electron stream that is graded in intensity. Tliis intensity is, as before stated, distributed in synchronism with the corresponding state of voltage across the corresponding crystals. of the array of the oscilloscope-like member .9. The sound, waves received successively by the crystal units along the successive rows and columns, as the units are rendered successively effective in the display circuit, will thus become converted into successive elemental portions of : the visual likeness, along correspondingly disjT5 posed rows and columns thereof, along the .suc---

(Jessive time bases. The elemental portions of the visual-picture likeness 123 of the object thus produced on the oscilloscope screen will accordingly correspond to the elemental portions of the sound energy picture on the array 26 of pick-up elements which, in turn, corresponds to the elemental portions of the actual object 3. A visual image 123 of the object 3 is thus produced on the screen 30.

The crystals of the bank 26 may be wafer thin in order to make possible the use of a sufficiently large number of them in the array 26 to provide for good definition. The frequency of the sound waves, for example, may be megacycles, corresponding to a wave-length of approximately 5xiO5 feet, in water, and produced, for example, by an oscillating quartz crystal, as described, for example, in an article by W. P. Mason and I. E. Pair, entitled "A New Direct CrystalControlled Oscillator for Ultra-Short-Wave Preiquencies," Proceedings of the Institute of Radio !Engineers, October, 1942, vol. 30, No. 11, pages 464 to 472. Lower-frequencied crystal oscillators may also be used, as described, for example, in an article by G. W. Fierce, entitled "Piezoelectric Crystal Oscillators Applied to the Precision Measurement of the Velocity of Sound in Air and CO at High Frequencies," Proceedings of the American Academy of Arts and Sciences, October, 1925, vol. 60, No. 5, pages to 295. Reference may be made also to W. G. Cady, Piezoelectricity, McGraw-Hill, 1946, pp. 501 to 506 and 682, and Kamayachi and Watanabe, Electrotechnical Journal of Japan, vol. 5, No. 1, 1941 pp. 19 and 20.

According to a further feature of the invention, it is possible to find the range of the object 3, assuming that its size is known. All that is necessary is to adjust the position of the lens 5 so as to produce a sharp sound image on the array 26 of pick-up elements; the range may then be obtained by simple geometrical optics. If, for example, the object 3 is a submarine of known size, the size of the visible likeness !23, divided by the known size of the submarine, will have the same ratio as the ratio between the distance of the lens 5 from the bank 26 of pickup elements, adjusted to obtain clear vision, divided by the distance of the object 3.

Although the invention has been described in connection with pick-up elements arranged in rows and columns, it will be understood that this is not essential, for other arrangements are also possible. Pick-up elements arranged along concentric circles covering the field, or along a continuous spiral, will also serve, though the oscilloscope arrangement would, of course, be correspondingly modified.

Further modifications will occur to persons skilled in the art, and all such are considered to lall 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. An electric system having, in combination, a bank of piezo-electric sound-receiving elements, means for focusing sound waves from an object upon the sound-receiving elements, a load circuit, means for permanently connecting the bank of receiving elements to the load circuit, means for scanning the receiving elements to develop signals in the load circuit representative of the sound-wave energy focused upon the receiving elements, and means operating in synchronism with the scanning means and responsive to the signals developed in the load circuit for producing a likeness of the object.

2. An electric system having, in coixibinatioii, a bank of sound-receiving elements, means for focusing sound waves from an object upon the sound-receiving elements, electron-beam scanning means associated with the receiving elements for successively scanning the elements to develop successive signals, and cathode-ray-oscilloscope means acting in synchronism with said scanning means and controlled in accordance with the signals for producing a likeness of the object.

3. An electric system having, in combination, a plurality of sound-receiving elements each capable of developing a voltage in response to received sound-wave energy, means for impressing sound waves upon the elements to develop a voltage upon each element, means for successively discharging the voltages, and means controlled by and synchronously with the discharge of the voltages for producing a likeness corresponding to the energy received by the corresponding element.

4. An electric system having, in combination, a plurality of sound-receiving elements each capable of developing a voltage in response to received sound-wave energy, means for impressing sound waves upon the elements to develop a voltage upon each element, means for successively discharging the voltages, a screen successively disposed areas of which correspond to the successively disposed elements, and means controlled by and synchronously with the discharge of each voltage for energizing the area corresponding to the corresponding element.

5. An electric system having, in combination, a plurality of sound-receiving elements each capable of developing a voltage in response to received sound-wave energy, means for impressing sound waves upon the elements to develop a voltage upon each element, means for successively discharging the voltages, an oscilloscope having a screen successively disposed areas of which correspond to the successively disposed elements, and means for sending an electron stream through the oscilloscope in synchronism with the discharge of the voltages to illuminate the areas in synchronism with the reception of the sound energy received by the corresponding elements.

6. An electric system having, in combination, a plurality of sound-receiving elements each capable of developing a voltage in response to received sound-wave energy, means for impressing sound waves upon the elements to develop a voltage upon each element, means for sending an electron stream to the elements successively to discharge them, an oscilloscope having a screen successively disposed areas of which correspond to the successively disposed elements, and means for sending an electron stream through the oscilloscope in synchronism with the first-named stream and for controlling the electron stream in accordance with the discharge of the elements to illuminate the areas in synchronism with the reception of the sound energy by the corresponding elements.

7. An electric system having, in combination, a plurality of sound-receiving elements capable of responding electrically when mechanically vibrated by sound waves from an object, each sound-receiving element corresponding to a predetermined elemental portion of the object from which it receives sound waves, means for producing scanning voltages, means responsive to the scanning voltages for scanning the successive sound-receiving elements thereby to scan the s2,528,73 sound waves received from the object, and means :. responsive to the scanning voltages and controlled by the electrical response of the successive soundreceiving elements produced when mechanically vibrated by the sound waves received from the - corresponding predetermined elemental portions of the object to produce a likeness of the corresponding successive elemental portions of the object.

9. An electric system having, in combination, ; cathode-ray apparatus comprising means for producing an electron stream, a mosaic provided so "with"a plurality of groups of piezo-electric elements substantially.-equally spaced-along a predetermined dimension, with the piezo-electric elements of each group substantially equally spaced along a second predetermined -dimension, the piezo-electric elements being mounted to vibrate individually and separately in response to sound waves impinging upon the respective piezo-electric elements, means for causing the electron stream to "scan successively the successive piezoelectric elements of each successive group of piezoelectric elements, an image-reproducing-means, and means operating synchronously with the scanning means and" responsive to the scanning of the successive piezo-electric elements for producing upon the image-reproducing means a likeness corresponding to the received sound waves.

11. An electric system having, - in combination, a cathode-ray apparatus comprising means--for producing an electron stream,: a:-onosaic "upon which the electron Stream mayvrmpinge provided with a plurality of groups of piezo-electric .elements having front and rear "surfaces1 "and substantially equally spaced along a predetermined dimension, with the piezo-electric elements of each group substantially equally spaced along a second predetermined dimension; the front surfaces of the elements being exposed to sound waves from an object and the rear "surfaces of rthe elements being exposeflto the electron stream within the cathodesrayixapparatus, means.-for "3; causing the electron stream to scan the rear surfaces of the piezo-electric elements, and means controlled synchronously with the scanning means "and responsive to the scanning of the piezo-electric elements for producing a likeness of the object.

12. An electric system having, in combination, -a cathode-ray apparatus comprising means for producing an electron stream, a mosaic of piezoelectric elements for receiving sound waves from an object, each element of the mosaic having two electrodes spaced a distance corresponding substantially to the width of the electron stream, means foreausing the electron stream to scan the piezo-eleetrie elements; and means controlled synchronously with the scanning means and .responsive to the scanning of the piezo-electric elements for producing a likeness of the object.

13. An electric system having, in combination, a cathode-ray-apparatus comprising means for producing an electron stream, a mosaic upon which the electron-stream may impinge provided with-a plurality of groups-of piezo-electric-elements substantially equally spaced along a predetermined dimension, with the piezo-electric elements of each group substantially equally spaced along a second predetermined dimension, the piezo-electric elements being mounted to vibrate individually and separately in response to sound waves from an object impinging upon the respective piezo-electric elements, each piezo-electric element having two electrodes connected in a common electric circuit, means for causing the electron stream to scan the piezo-electric elements -in order to produce electrical signals in the electric circuit, and means responsive to the electrical signals7 and controlled synchronously with the scanning means for producing a likeness of the Object. ; 14. An electric system having, in combination, a-mosaic comprising a

two-dimensional array of sound-receiving elements for - receiving sound waves from an object, means for producing an electron stream impinging on the elements, an electric circuit in which the elements are connected for producing a likeness corresponding to the sound energy received by the elements from the object, means for causing the stream to scan the elements in two-dimensional order, thereby to produce -successive signals in the electric circuit,-and means controlled in synchronism with -; the scanning means and responsive to the signals in the electric circuit to produce successive portions oflikeness of the object in two-dimensional order synchronously with the reception of the sound energy from the object by the receiving elements.

16. An electric .system having, in combination, sound-receiving means the dimensions of which : vary. in-response to /the received sound -waves, means for producing an electron stream impinging on the sound-receiving means, means for causing the electron stream to scan the soundreceiving means, an electric circuit in which the sound-receiving means is connected, and means for directing sound energy on the sound-receiving means to produce changes in the dimensions of the sound-receiving means, thereby to vary the current in the circuit as the electron stream scans the sound-receiving means.

17. In combination, means for imaging sound waves from a scene to be reproduced, a soundwave pick-up device comprising piezo-electric means, means for producing scanning voltages, means responsive to the scanning voltages for scanning an area successive portions of which correspond to successive portions of the soundwave image, means controlled in accordance with the scanning for converting the energy picked up during the scanning by the pick-up device from the different portions of the image into corresponding electrical signals, a display cathode-ray tube, means responsive to the scanning voltages for operating the tube in synchronism with the scanning, and means for supplying the signals 2r& gt; to the tube, whereby a picture of the scene is obtained.

18. In combination, means for imaging sound waves from a scene to be reproduced, a soundwave pick-up device comprising mechanically 3o vibratory means, means for producing scanning voltages, means responsive to the scanning voltages for scanning an area successive portions of which correspond to successive portions of the sound-wave image, means controlled in accord- ; jfl ance with the scanning for converting the energy picked up during the scanning by the pick-up device from the different portions of the image into corresponding electrical signals, an imagereproducing means, means responsive to the scanning voltages for operating the image-reproducing means in synchronism with the scanning, and means for supplying the signals to the imagereproducing means, whereby a picture of the scene is obtained.

19. A system for transforming an image formed by sound waves into an image formed by electromagnetic waves, said system comprising a plurality of spaced sound-receiving elements each having two conductive surfaces separated by a piezo-electric element, means for impinging the sound waves of the sound-wave image upon the receiving elements, each said receiving element being poled with the conductive direction of each element the same as any other with respect to the ,,,-& gt; plane of the sound-wave image, whereby the sound intensity variation at any given point in the sound-wave image gives rise to alternating currents on the conductive surfaces of a particular one of said receiving elements in proportion uo to the sound intensity at the given point, means periodically discharging said receiving elements in succession, thereby producing a fluctuating current varying in accordance with the magnitude of the alternating currents from element to (. element, and means producing an electromagnetic image from the information carried by the fluctuations in said current.

20. An electric system having, in combination, means comprising a plurality of vibratile elements for receiving sound waves from an object, each element being capable of translating sound waves received by it into electrical waves of intensity corresponding to the intensity of the received sound waves, means for focusing a soundwave image of the object upon the receiving elements, a load circuit, means for permanently connecting the plurality of receiving elements to the load circuit to develop electric-wave signals representative of the sound-wave energy focused upon the receiving elements, means for scanning the elements thereby to scan the sound-wave image, and means connected to the load circuit operating in synchronism with the scanning and responsive to the electric-wave signals translated from the received sound waves by the receiving elements and developed in the load circuit for producing a likeness of the object.

21. An electric system having, in combination, a plurality of sound-receiving elements for receiving sound waves from an object, each element being capable of translating sound waves received by it into corresponding electric energy, a load circuit, means for connecting the plurality of receiving elements to the load circuit simultaneously to produce electric energy in the load circuit representing the resultant of the electric energy produced by all of the plurality of receiving elements, means for instantaneously diminishing said resultant of the electric energy by quantities corresponding to the electric energy translated by the successive sound-receiving elements from the sound waves received thereby, and means operating synchronously with the diminishing means connected to the load circuit and responsive to the electric waves for producing a likeness of the object.

22. An electric system having, in combination, a plurality of vibratile means for receiving sound waves and translating the received sound waves into corresponding electric energy, means for focusing sound waves from an object upon the sound-wave receiving means, a load circuit comprising an amplifier, means for producing a biasing voltage, means for permanently connecting the biasing-voltage-producing means and the sound-wave receiving means to the load circuit, and means connected to the amplifier and responsive to the electric energy translated from the received sound waves by the receiving means for producing a likeness of the object.

23. An electric system having, in combination, sound-energy receiving means capable of responding electrically in response to sound energy received thereby, means for producing electrons for varying the electrical response of the soundenergy receiving means thereby to develop a signal, and means controlled by the signal for producing an indication corresponding to the sound energy received by the sound-energy receiving means.

24. An electric system having, in combination, mechanically vibratory means adapted to be set into mechanical vibration in response to sound energy impinging thereon and capable of responding electrically when vibrated mechanically, means for producing electrons for varying the electrical response of the mechanically vibratory means when vibrated mechanically thereby to develop a signal, and means controlled by the signal for producing an indication corresponding to the sound energy impinged upon the mechanically vibratory means.

25. An electric system having, in combination, mechanically vibratory means adapted to be set into mechanical vibration in response to sound energy impinging thereon and capable of responding electrically when vibrated mechanically, means for impinging electrons upon the mechanically vibratory means to vary the elec2,528; 72 trical response of the mechanically vibratory means when vibrated mechanically thereby to develop-a signal, and means controlled by the signal for producing an indication corresponding xto: the sound energy impinged upon the mechanically vibratory means.

26, An electric system having, in combination, a.. plurality of mechanically vibratory .means adapted: to be set into mechanical vibration in response to sound energy impinging thereon and capable of responding electrically when vibrated mechanically, means comprising an electron stream for scanning the mechanically vibratory .means to vary the electrical response of the mechanically vibratory means when vibrated mechanically thereby to develop successive signals, and means controlled in accordance with the signals and synchronously with the scanning . effected by the scanning means for producing an . indication corresponding to the sound energy .impinged upon the mechanically vibratory : means.

.-27. An electric system having, in combination, : a plurality of mechanically vibratory means .-adapted to be set into mechanical vibration in v response to sound waves impinging thereon and capable of responding electrically when vibrated -. mechanically, means for converging sound ..energy emanating from an object upon the mechanically vibratory means to set the me-, chanically vibratory means into mechanical vibration, means comprising an electron stream .for scanning the mechanically vibratory means to vary the electrical response of the mechanically vibratory means when vibrated mechanically thereby to develop successive signals, and .means controlled in accordance with the signals and synchronously with the scanning effected ,: by the scanning means for producing a likeness of the object.

28. An electric system having, in combination, a plurality of piezoelectric means, means for converging sound

energy emanating from an object upon the piezoelectric means to set the piezoelectricmeans into mechanical vibration, means comprising an electron stream for scanning the .-piezoelectric means to vary the electrical response of the piezoelectric means when vibrated . mechanically thereby to develop successive sig- : nals,: and means controlled in accordance with . the -signals and synchronously with the scanning . produced by the scanning means for producing a likeness of the object.

29. An electric system having, in combination, ,: a plurality -of .mechanically vibratory, sound-receiving elements each adapted to be set into mechanical vibration in response to sound energy impinging thereon and each capable of respondingelectrically when vibrated mechanically, -.means for converging sound energy emanating -from an object upon the mechanically vibratory elements: to set the mechanically vibratory elements into mechanical" vibration, means comprising-an electron stream for successively scanning-the mechanically vibratory elements successively to vary the electrical response of the mechanically vibratory elements when vibrated mechanically thereby to develop successive signals, and means controlled in accordance with the signals and synchronously with the scanning effected by the scanning means for producing a likeness of the object.

30. An electric system having, in combination, a-plurality of piezoelectric sound-receiving ele-

-iments, Bmeans .for converging, soundenergy, emanating from an object .upon the piezoelectric elements to set the piezoelectric elements into mechanical vibration, means .comprising an. eleetron stream for successively .scanning therpiezos electric elements thereby to develop - successive signals, and means-controlled in-accordance with the -signals .and synchronously.: with the -scanning effected by the scanning means for producing a likeness of the object.

31. An electric system having, in combination, a plurality of mechanically vibratory ..means adapted to -be set -into mechanical vibration -in response to sound waves impinging thereon, and -capable of responding electrically when vibrated mechanically, means for converging sound : ener- -: gy emanating from an object upon the mechanically vibratory means to set the mechanically vibratory means into mechanical vibration, -means comprising an electron stream for scanning the mechanically vibratory means to vary the electrical response of the mechanically vibratory means When vibrated mechanically thereby -to develop successive signals, a cathode-ray oscilloscope having a screen and means, for pro-

: ducing an electron stream for scanning-the screen, and means controlled in accordance with the signals and synchronously with the scanningj effected by the scanning means for controlling the scanning operation of the electron ;!0 stream of the oscilloscope to produce a likeness of the object upon the screen.

";32. An electric system having, in combination, a plurality of piezo-electric means, means for converging sound energy emanating from an ob35--ject upon the piezoelectric means to set the piezoelectric means into mechanical vibration, means comprising an electron stream for effecting; the scanning of the piezoelectric means to vary the electrical response of the piezoelectric means when vibrated mechanically thereby to develop successive signals, a cathode-ray oscilloscope having a screen and means for producing an-electron stream for scanning the screen, and means controlled in accordance with the 45. signals and synchronously with the scanning effected by the first-named scanning means for controlling the scanning operation of the electron stream of the oscilloscope to produce a likeness of the object upon the screen.

33. An electric system having, in combination, a plurality of mechanically vibratory elements each adapted to be-set into mechanical vibration in response to sound energy impinging thereon and . each capable of responding electrically when vibrated-mechanically, means for converging sound energy emanating from an object upon the .mechanically vibratory elements to set the mechanically vibratory elements into mechanical vibration, means comprising - an electron stream for successively scanning the soundreceiving elements successively to vary the electrical response of the mechanically vibratory elements when vibrated mechanically thereby to develop successive signals, a cathode-ray oscilloscope having a screen and means for producing an electron stream for scanning the screen, and means controlled in accordance with the signals and synchronously with the scanning effected by the scanning

means for controlling the scanning operation of the electron stream : of the oscilloscope to produce a likeness of the object upon the screen. - 34. An electric system having, in combination, r a-ia:-plurality : of piezoelectric soundsreceiving elements, means for converging sound energy emanating from an object upon the piezoelectric elements to set the piezoelectric elements into mechanical vibration, means comprising an electron stream for successively scanning the piezoelectric elements thereby to develop successive signals, a cathode-ray oscilloscope having a screen and means for producing an electron stream for scanning the screen, and means controlled in accordance with the signals and synchronously with the scanning effected by the scanning means for controlling the scanning operation of the electron stream of the oscilloscope to produce a likeness of the object upon the screen.

35. An electric system having, in combination, a plurality of mechanically vibratory means adapted to be set into mechanical vibration in response to sound energy impinging thereon and capable of responding electrically when vibrated mechanically, means for converging sound energy emanating from an object upon the mechanically vibratory means to set the mechanically vibratory means into mechanical vibration, a load circuit, means for permanently connecting the mechanically vibratory means to the load circuit, means for scanning the mechanically vibratory means to develop in the load circuit signals representative of the sound energy converged upon the mechanically vibratory means, and means connected to the load circuit and responsive to the signals developed therein for producing a likeness of the object.

36. An electric system having, in combination, a plurality of piezoelectric sound-receiving elements, means for converging sound energy emanating from an object upon the piezo-electric elements to set the piezo-electric elements into mechanical vibration, a load circuit, means for connecting all the plurality of piezo-electric elements to the load circuit simultaneously to produce electric energy in the load circuit representing the resultant of the electric energy produced by all the piezo-electric elements, means comprising an electron stream for successively scanning piezo-electric elements in order to diminish the said resultant of the electric energy during the scanning of the respective piezo-electric elements by quantities corresponding to the . sound energy converged upon them by the converging means from the object, and means operable synchronously with the diminishing means connected to the load circuit for producing a likeness of the object.

37. An electric system having, in combination, a plurality of piezoelectric sound-receiving elements, means for converging sound energy emanating from an object upon the piezoelectric elements to set the piezoelectric elements into mechanical vibration each with an intensity corresponding to the intensity of the sound energy emanating from the component part of the object from which the sound energy impinging thereon emanates, means for enhancing the mechanical vibration set up in the piezoelectric elements, means for scanning the successive piezoelectric elements thereby to develop corresponding signals, and means operable as each piezoelectric element is scanned for producing, in a region corresponding to the component part of the object from which the sound-energy impinging on such piezoelectric element emanates, in response to the corresponding signal an illumination of intensity corresponding to the intensity of the sound energy emanating from such component part of the object, thereby to produce a likeness of the object.

38. An electric system having, in combination, a plurality of piezoelectric sound-energy receiving elements for receiving sound waves from an object, a plurality of spaced electrodes respectively associated with each of the plurality of receiving elements, the electrode spacing providing sufficient capacitance to produce resonance to the frequency of the received sound waves, means for scanning the receiving elements to develop signals, and means responsive to the signals and controlled synchronously with the scanning for producing a likeness of the object.

39. An electric system having, in combination, piezoelectric means of the type that produces electric energy when vibrated meehanicaly, means for converging sound energy emanating from an object upon the piezoelectric means to set the piezoelectric means into mechanical vibration thereby to produce electric energy, means for producing a biasing voltage to sensitize the piezoelectric means, and means controlled in accordance with the electric energy produced by the mechanical vibrations of the piezoelectric means for producing a likeness of the object.

40. An electric system having, in combination, mechanically vibratory sound-energy receiving means, means for converging sound energy emanating from an object upon the sound-energy receiving means to set the sound-energy receiving means into mechanical vibration thereby to produce electric energy, means for producing a biasing voltage to sensitize the sound-wave receiving means, and means controlled in accordance with the electric energy produced by the mechanical vibrations of the sound-energy receiving means for producing a likeness of the object.

41. An electric system having, in combination, a bank of Rochelle-salt piezo-electric sound-receiving elements, means for focusing sound waves from an object upon the sound-receiving elements, a load circuit, means for permanently connecting the bank of receiving elements to the load circuit, means for scanning the receiving elements to develop signals in the load circuit representative of the sound-wave energy focused upon the receiving elements, and means operating in synchronism with the scanning means and responsive to the signals developed in the load circuit for producing a likeness of the object.

42. An electric system having, in combination, a bank of quartz piezo-electric sound-receiving elements, means for focusing sound waves from an object upon the sound-receiving elements, a load circuit, means for permanently connecting the bank of receiving elements to the load circuit, means for scanning the receiving elements to develop signals in the load circuit representative of the sound-wave energy focused upon the receiving elements, and means operating in synchronism with the scanning means and responsive to the signals developed in the load circuit for producing a likeness of the object.

43. An electric system having, in combination, a bank of di-hydrogen potassium phosphate piezo-electric sound-receiving elements, means for focusing sound waves from an object upon the sound-receiving elements, a load circuit, means for permanently connecting the bank of receiving elements to the load circuit, means for scanning the receiving elements to develop signals in the load circuit representative of the sound-wave energy focused upon the receiving elements, and means operating in synchronism with the scanning means and responsive to the signals developed in the load circuit for producing a likeness of the object.

ROBERT HARVEY RINES.

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