Nov. 17, 1964 B. HASKELL 3,157,822

IMPEDANCE NETWORKS AND DISPLAY PANELS UTILIZING THE NETWORKS

Filed Dec. 30, 1960

FIG. 1

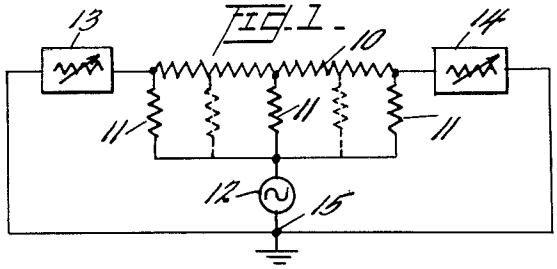



FIG. 2

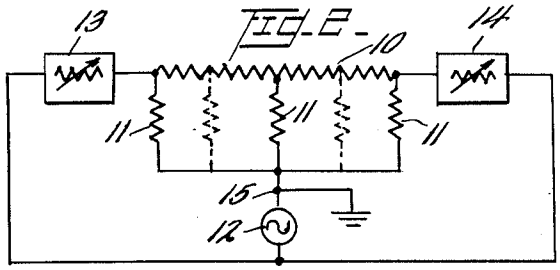



FIG. 3

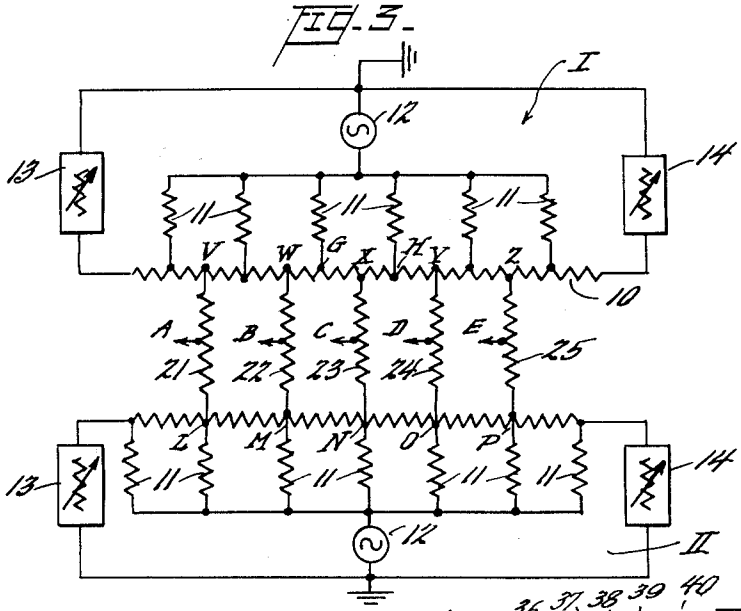



FIG. 4A

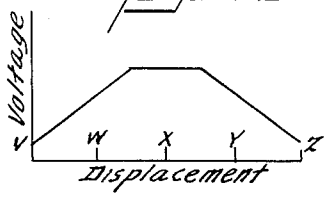



FIG. 4B

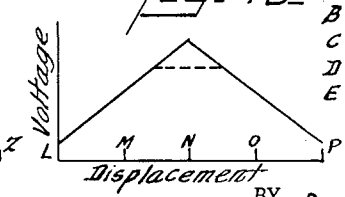
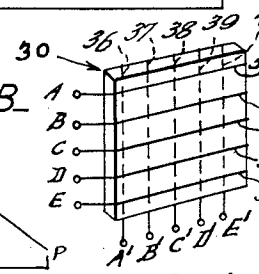



FIG. 5




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3,157,822

# IMPEDANCE NETWORKS AND DISPLAY PANELS UTILIZING THE NETWORKS

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20 Claims. (Cl. 315—169)

This application is a continuation in part of copending application S.N. 60,216, filed October 3, 1960, now Patent No. 3,102,970, granted September 3, 1963 by Boris Haskell and George Edlen.

The present invention relates to impedance networks, and to display panels utilizing such networks for the purpose of presenting electrically carried intelligence in visual or other form. The networks of the present invention are adapted to commutate or gate the incoming electrical intelligence to selected or various areas of the panel in accordance with a prescribed or desired commutation or gating pattern, in order to present the electrical information in intelligible visual form or other form adapted for display. Accordingly, the impedance networks may themselves be considered as commutating or gating circuits for general purposes other than display panels.

With respect to the display panels, it is contemplated that the present commutating or gating impedance networks may be particularly advantageously used for scanning electroluminescent display panels, although the present invention is not limited to such specific panels. Electroluminescent panels adapted to emit light in response to a varying electrical field applied thereacross are well known, and are exemplified by such U.S. patents as 2,728,870 to W. C. Gungle, et al., and 2,624,857 to E. L. Nager. In addition, it has been recognized that if an intelligence bearing electrical signal is applied across localized areas of an electroluminescent panel in accordance with a prescribed scan pattern, the electrical intelligence can be converted into an intelligible visual light output of the panel. A primary problem in this regard is obtaining a practical means and method for effecting a controlled and predetermined scanning pattern for the electroluminescent panel. The prevalent prior art approach to scanning such a panel is based upon sandwiching the electroluminescent phosphor panel between two conductive grids. A first grid of parallel conductors is placed on one surface of the panel, and a second grid of parallel conductors is placed on the opposite surface of the panel. These grids are further arranged to lie at right angles to each other, and thus provide a pattern of intersecting points. It is apparent that these intersection points can be selectively energized by selectively applying a potential across the two conductors that form the particular intersection. Appropriate selective energization of the grid conductors can thus provide a desired pattern of scan. One prior art method of effecting this selective energization of the grid conductors is to associate a conventional commutator with each grid, as exemplified in U.S. Patent 2,698,915 to W. W. Piper. A second prior art approach is to associate a delay line with each grid, so that a pulse applied to one end of the line sequentially energizes each of the grid conductors associated therewith, as exemplified in U.S. Patent 2,818,531 to S. C. Peek, Jr.

The conventional commutator approach has the obvious disadvantage of a rather cumbersome device, particularly where each grid comprises a large number of conductors. The delay line approach suffers from the disadvantage of requiring a very long delay line if the field of scan is to span any appreciable length of time, as well as from the problem of attenuation of the pulse as it travels down the line. The present invention overcomes the foregoing disadvantages, and provides a simple and effective approach to scanning an electroluminescent panel by



means of a novel impedance network adapted to function as an electrical commutator or gating circuit for the panel. Further, whereas the foregoing prior art approaches are inherently limited to scanning on a fixed pattern in accordance with the precise pattern designed into the structure of the system, in accordance with the present invention, the scan pattern may be altered at will by merely changing an electrical input to the scanning system. As a result, the electroluminescent display panels of the present invention take on the characteristics of an oscilloscope, and may be used to trace the voltage characteristics, for example, of an input signal, as well as to effect a visual presentation of electrically carried intelligence on the basis of a prescribed pattern of scan properly referenced to the pattern of application of electrical intelligence.

Since the novel impedance networks of the present invention function as commutating or gating circuits in scanning the electroluminescent display panel, it is apparent that these networks can function as electrical commutators or gating circuits in general, for purposes other than scanning such display panels. Accordingly, the present invention contemplates these general commutating and gating functions of the impedance networks, as well as other functions and uses to which these novel networks may be put, as will be apparent to those skilled in the art.

It is therefore one object of the present invention to provide display panels, and particularly electroluminescent display panels.

Another object of the present invention is to provide for scanning display panels.

Another object of the present invention is to provide for scanning such panels in accordance with a prescribed pattern of scan.

Another object of the present invention is to provide for such a prescribed pattern of scan and for developing a visual presentation of electrically carried intelligence properly referenced to said pattern of scan.

Another object of the present invention is to provide for scanning display panels, and particularly electroluminescent panels, wherein the pattern of scan is a function of the characteristics of an applied electrical value, and may be a function of applied voltage values.

Still another object of the present invention is to provide novel impedance networks, particularly adapted to function as electrical commutating and gating circuits, and to perform other functions not normally attributable to impedance networks.

Other objects and advantages of the present invention will become apparent to those skilled in the art from a consideration of the following detailed exemplary description thereof, had in conjunction with the accompanying drawings, in which like numerals refer to like or corresponding parts, and wherein:

FIG. 1 is a schematic diagram of an electrical impedance network forming a basic component or unit of the present invention;

FIG. 2 is a schematic diagram of a second electrical impedance network also forming a basic component or unit of the present invention;

FIG. 3 is a schematic diagram of two network units of FIG. 1 connected back to back, and exemplifying the network of the present invention;

FIGS. 4A and 4B are schematic plots of the voltage distributions appearing across the two network units of FIG. 3; and

FIG. 5 is a schematic diagram of an electroluminescent panel, having crossed grids, and indicated as coupled to two separate networks of the type illustrated in FIG. 3, for horizontal and vertical scan; and for luminance intelligence as well, if desired.

Before describing the network of the present invention

and its relation to electroluminescent display panels, attention will first be given to the basic impedance network units utilized by the present invention, and schematically shown in FIGS. 1 and 2. In FIGS. 1 and 2, a voltage source 12 is shown coupled to a resistor 10 through a plurality of parallel resistors 11, the resistors 11 being coupled to spaced points along the length of resistor 10, thus forming a resistance coupling to resistor 10 distributed along the length thereof. Any desired number of resistors 11 may be employed, three being shown for purposes of illustration. To the ends of resistor 10 are coupled variable impedances 13 and 14, which may for example be impedances variable mechanically, such as potentiometers, or impedances variable electrically, such as impedance vacuum tube circuits, or variable voltage sources bucking source 12 and effectively operating as variable impedances. The variable impedance devices 13, 14 are in turn coupled together and to the source 12 to complete the circuit. Structurally the circuits of FIGS. 1 and 2 are identical. In FIG. 1 however the connection between the variable impedances 13, 14 and the source 12 is indicated as grounded at 15, while in FIG. 2 the opposite or other side of the source 12 is indicated as grounded at 15.

In FIG. 1, if the impedances 13 and 14 are equal, the voltage distribution on resistor 10 has a maximum value with reference to ground 15 at the center, and diminishes toward either end of the resistor 10. If the impedance of 13 is increased and that of 14 decreased, this maximum voltage point on resistor 10 moves to the left. Similarly, if the impedance of 14 is increased and 13 is decreased, the maximum voltage point on resistor 10 moves to the right. Thus, the maximum voltage point on resistor 10 can be caused to move therealong in accordance with the variations in impedance values of variable impedance units 13 and 14. If desired, the impedance values of this network can be readily chosen so that if the increase in impedance of one unit 13 or 14 is balanced by a corresponding decrease in impedance of the other unit, the value of the voltage of the moving maximum point remains constant for a constant output from source 12, for each instance that this maximum is at a junction of one of the resistors 11 with resistor 10.

This movement of the maximum voltage point along resistor 10 is caused by a shift in the impedance value of one side of the network relative to the other, thereby causing a shift in the impedance midpoint of the network as related to the length of elongate resistor 10. Since it is only the voltage distribution along resistor 10 that is of concern in the present invention, this impedance midpoint (the impedance midpoint of the network relative to the physical dimension of the network related to the length of elongate resistor 10) is referred to herein as the "effective impedance midpoint" of the network.

The operation of the FIG. 2 circuit is exactly the same as the FIG. 1 circuit, except that the maximum voltage point of FIG. 1 is replaced by a minimum voltage point with reference to ground 15 in FIG. 2 that may be caused to traverse resistor 10 in the same manner and under the same conditions as discussed above with reference to FIG. 1. Of course, the term "effective impedance midpoint" of the network applies to the traversing minimum voltage embodiment as well as the traversing maximum voltage embodiment.

In the foregoing networks of FIGS. 1 and 2, it will be appreciated that since variable impedance units 13 and 14 may take on numerous forms, as for example impedance vacuum tube circuits or variable voltage sources of diverse types functioning effectively as variable impedances, the impedance values of these units may be readily varied in accordance with the value of an incoming or applied signal, as for example a voltage signal. As the maximum or minimum voltage point on resistor 10 is thus caused to move, the unit broadly constitutes a means for converting the value of an applied signal (i.e. the signal applied to control the impedance values of units 13 and 14) into a spatial displacement related to the value of said applied signal. This phenomenon may be employed for many purposes, and one purpose is to effect a spatial commutating, selecting, or energizing function along the length of resistor 10, and such function may be employed for the purposes of scanning a crossed grid electroluminescent screen, as fully explained in the copending application of Boris Haskell and George Edlen, S.N. 60,216, filed October 3, 1960, of which the present application is a continuation-in-part, and the disclosure of said copending application is incorporated herein by reference.

As pointed out in said copending application, when scanning or commutating with the networks of FIGS. 1 and 2, distinction between the maximum (or minimum) voltage point and the lesser voltage points adjacent thereto along the network or resistor 10 is not sharp, because of the gradual voltage changes along the entire length of the resistor 10. In accordance with the present invention, a modification of the networks of FIGS. 1 and 2 is provided, whereby one obtains a sharp distinction between the traversing maximum (or minimum) voltage point and all other points along resistor 10. Indeed, all outputs from the network, except that one corresponding to the position of the voltage maximum (or minimum), may be held at a zero voltage value, while the maximum (or minimum) output point may be varied to any desired voltage value.

The commutating network of the present invention is illustrated in FIG. 3, wherein two FIG. 1 network units indicated as I and II are connected back to back; that is, points V, W, X, Y, and Z of network unit I are connected by resistors 21, 22, 23, 24, and 25 to points L, M, N, O, and P of network unit II. The outputs from this resultant or compound network are tapped from appropriate points on resistors 21, 22, 23, 24, and 25, as indicated at A, B, C, D, and E.

Points L, M, N, O, and P in network unit II correspond to junctions between parallel resistors 11 and resistor 10. In network unit I, however, tapped points V, W, X, Y, and Z are midway between the junctions of parallel resistors 11 with resistor 10. The difference in voltage distribution patterns resulting from this difference in the manner of tapping the two network units is illustrated in FIGS. 4A and 4B. It is assumed, for purpose of example, that both network units I and II are balanced, i.e., that the effective impedance midpoints of the network units are located at the centers of their respective resistors 10. It is further established, for the present example, that points X and N are the effective impedance midpoints for their respective network units. FIG. 4A diagrammatically illustrates the voltage pattern existing along resistor 10 of network unit I, while FIG. 4B diagrammatically illustrates the voltage pattern existing along resistor 10 of network unit II. Network unit II has a voltage peak appearing at the junction N between resistor 10 and the central resistor 11. In network unit I, however, there is no resistor 11 connecting source 12 to the center point X of resistor 10, and with junctions G and H located symmetrically to either side of center point X, points G, H, and X are all at the same voltage value, resulting in a voltage plateau shown in the voltage distribution diagram of FIG. 4A for network unit I. This plateau is also superposed as a dotted line, for illustration purposes, on the voltage distribution diagram of FIG. 4B for network unit II. In FIGS. 4A and 4B, the voltage plateau is shown as flat on the idealized assumption of equal voltage at points G, H, and X. This idealized assumption is not entirely accurate because of coupling between network units I and II. However, this coupling can be minimized and rendered negligible, and a near idealized result obtained by making resistors 21, 22, 23, 24, and 25 much higher than other pertinent impedance values in the network units, as would be apparent to those skilled in the art.

The parameters of resistance values and applied voltage values may be chosen so that the voltage distribution curve along resistor **10** of network unit I is substantially congruent with the curve along resistor **10** of network unit II except for the peak and plateau; that is, the voltage at V equals the voltage at L, W equals M, Y equals O, and Z equals P. The voltage at point N, of course, exceeds that at X, and the value of the voltage difference between N and X may be varied by varying the voltages of sources **12**. Such variations should be effected by equal changes in the voltages of sources **12** of both network units I and II in order to maintain the equality of voltages at all other tapped points of these two network units.

Under the conditions above described, if the voltage applied from source **12** of network unit I is 180° out of phase (or opposite in sign for D.C. voltages) with the voltage from source **12** of network unit II, and if points A, B, C, D, and E are center taps from resistors **21**, **22**, **23**, **24**, and **25**, there is zero voltage output from taps A, B, D, and E, and a voltage output is obtained only from tap C. By varying the impedance values of units **13** and **14** for both network units I and II simultaneously and correspondingly, the maximum peak voltage of network unit II is caused to traverse its resistor **10** to the left or right depending on the direction of change of impedances **13** and **14**, while the plateau voltage point of network unit I is caused to traverse its resistor **10** simultaneously and correspondingly. Thus, the single output point is switched between the points A, B, C, D, and E in accordance with the traverse of said peak and plateau voltages across resistors **10** of network units II and I.

It might also be mentioned that a given single activated output point reduces to a zero output, i.e., goes onto the congruity portion of the two voltage distribution curves, as the next output point begins to become activated, or moves off the congruity portion of the two voltage curves. Thus, as the output traverses to successive output taps A, B, C, D, and E, only one tap is activated at a time, and there is no transition period of dual activation of two output taps.

The compound network of FIG. 3 may be used for many commutating and gating functions in various environments. One commutating function for which the present invention is adapted, is the scanning and activation of electroluminescent display panels or scanning spot generators. This function is illustrated in FIG. 5. The numeral **30** designates an electroluminescent panel of known form, construction, and composition. Across one face of the panel **30** are layed a plurality of parallel spaced electrical conductors **31–35**. A second set of parallel spaced electrical conductors **36–40** are layed across the opposite surface or face of the panel **30**. The second set or grid of conductors are applied to the panel preferably at right angles to the first set or grid of conductors, to provide a crossed grids arrangement forming a plurality of distinct intersecting points between the conductors of one grid and the conductors of the other grid. These grids are both electrically coupled directly to the electroluminescent panel **30** and are capacitively coupled to each other through the panel. Thus, when a varying electrical field appears between one conductor of one grid and one conductor of the other grid, the spot or area of the panel located at the intersection of these two conductors is caused to luminesce in accordance with the voltage and/or frequency of the varying electrical field therebetween.

Scanning of the cross grids panel is effected by means of two networks of the type illustrated in FIG. 3. For example, output points A, B, C, D, and E of the network of FIG. 3 may be connected to input points A, B, C, D, and E of FIG. 5. A second network, similar to that of FIG. 3, but designed to produce a traversing output from points corresponding to points A, B, C, D, and E of FIG. 3, opposite in phase or sign from that had in FIG. 3, is applied to the inputs A′, B′, C′, D′, and E′ of FIG. 5. This traversing output of opposite phase or sign is obtained simply by reversing the phase relationship of the voltage sources **12** for network units I and II, so that the peak voltage from network unit II of one scanning network for one grid is opposite in phase or sign to the peak voltage from network unit I of the other scanning network for the other grid.



Therefore, by varying the effective values of the impedance units **13** and **14** of the scanning network for grid **31–35** in accordance with either a step function or sawtooth function, one obtains a vertical scan of the panel **30**. Similarly, by varying the effective values of the impedance units **13** and **14** of the scanning network for grid **36–40** in accordance with either a step or sawtooth function, one obtains a horizontal scan of the panel **30**. During simultaneous vertical and horizontal scan, since only one conductor of grid **31–35** and only one conductor of grid **36–40** are energized at any one instant, only one point at a time on panel **30** is caused to be activated to luminescence. Due to phosphor and visual persistence however, a complete scan frame can be observed if the rate of scan is sufficiently rapid, as would be obvious to one skilled in the art.

By approximately relating the rate of horizontal scan to vertical scan, the pattern of scan can of course be preset by suitable circuitry to afford a line-by-line pattern of scan to cover the entire field of the panel **30** in one scanning cycle, and interlaced fields of scan can be utilized if desired. On the other hand, the preset scan may simply be a repetitive horizontal sweep for the purpose of tracing out an input waveform applied to the vertical scanning network, in the same manner as a conventional oscilloscope. It is understood that for any pattern of scan employed, it is contemplated that where desired the scan field or frame may be repeated repetitively. For this purpose, a switch or gating device (not shown) may be employed where necessary with the voltage sources **12**, synchronized with or controlled by the input signals applied to the variable impedance units **13**, **14**, to cut off application of voltages to the scanning grids during the time that the variable impedance units **13**, **14** are returned to their field of scan starting values. Where necessary a similar technique may obviously be employed for what would correspond to the fly-back time on each horizontal line of scan.

As indicated previously, luminance intelligence can be applied to the present system by modulation of the voltage sources **12**, since the only effect of a simultaneous increase or decrease of the voltage values of sources **12** of both network units I and II is to increase the voltage of only the particular output tap A–E that is energized at the moment. Another feature of the present invention resides in the ability of the present scanning networks to create a desired degree of general background luminescence for panel **30**. This is accomplished preferably by varying the value of voltage from source **12** of network unit I relative to the value of voltage from source **12** of network unit II, thereby creating some level of output at all tap points A–E at all times. The same result could be obtained by changing the tap positions of points A–E on resistors **21–25**. This general background luminance would be obtained through the scanning network for one grid, while the luminance intelligence would be obtained through the scanning network for the other grid, in order that luminance intelligence variations would not cause variations in the general background luminance.

In FIG. 3, voltage source **12** for network unit I is indicated as separate from source **12** for network unit II. It is understood, of course, that both these voltages can be derived from the same source. Also, although shown as A.C. energized, it is obvious that the network and the network units can be energized by D.C. voltages; and D.C. network energizing voltages could even be used for the electroluminescent display panel embodiment of FIG.

5, relying on the moving scan pattern and changing luminance intelligence for a change in electrical field to obtain luminescence. It should also be appreciated that other electrically responsive display and/or recording media may be substituted for the electroluminescent panel **30**, such as an array of voltage responsive glow tubes or a recording paper or sheet adapted to provide an impression in response to the application of an electrical signal thereto. Although the network is shown in FIG. 3 as a five position commutator, and the crossed grids panel in FIG. 5 as five line grids, it is obvious that any number of commutator positions and grid lines may be provided. Also, it is apparent that the panel **30** may be a continuous electroluminescent panel, or a mosaic, as desired.

Having thus described a specific embodiment of the impedance network of the present invention for obtaining electrical spatial displacements related to electrical or other input functions, and of a scanning spot generator or display panel employing such network, it is understood that these embodiments are intended merely as exemplary of the present invention, and it is not intended that the invention be considered as limited to the specific uses and details herein described. Rather, since other uses and variations and modifications of these embodiments will be readily apparent to those skilled in the art, such changes as are embraced by the spirit and scope of the appended claims are contemplated as within the purview of the present invention.

What is claimed is:

1. An electroluminescent display panel comprising: an electroluminescent panel, a first grid of substantially parallel electrical conductors on one face of said panel, a second grid of substantially parallel electrical conductors on the other face of said panel, the conductors of one grid being oriented at an angle to the conductors of the other grid to provide a plurality of intersecting points between the conductors of one grid and the conductor of the other grid; a scanning network associated with each grid; each scanning network comprising first and second network units; each network unit comprising an impedance member having two terminals, a plurality of impedance elements for coupling one side of an input voltage source to spaced points along said member intermediate said terminals, means for coupling both terminals of said member to each other and to the other side of said voltage source, and means for varying the effective impedance midpoint of the network unit; impedance means coupling spaced points along said member of one unit to spaced points along said member of the other unit of the scanning network; and means coupling the conductors of each grid to respective ones of said impedance means of the scanning network associated with such grid.

2. An electroluminescent display panel as set forth in claim 1, wherein said impedance member, impedance elements, and impedance means are resistances.

3. An electroluminescent display panel as set forth in claim 1, wherein said means for varying the effective impedance midpoint of said network unit comprises a variable impedance interposed between one terminal of said impedance member and said other side of said voltage source.

4. An electroluminescent display panel comprising: an electroluminescent panel, a first grid of substantially parallel electrical conductors on one face of said panel, a second grid of substantially parallel electrical conductors on the other face of said panel, the conductors of one grid being oriented at an angle to the conductors of the other grid to provide a plurality of intersecting points between the conductors of one grid and the conductors of the other grid; a scanning network associated with each grid; each scanning network comprising first and second network units; each network unit comprising an impedance member, means for producing a voltage distribution pattern along said member having an area of maximum positive or maximum negative voltage, and means for varying the location of said area along said member; said two units being related to provide a maximum voltage difference between the voltage distribution patterns on the two units at said areas; impedance means coupling spaced points along said member of one unit with spaced points along said member of the other unit; and means coupling the conductors of each grid to respective ones of said impedance means of the scanning network associated with such grid.

5. A network comprising first and second network units, each network unit comprising an impedance member, means for producing a voltage distribution pattern along said member having an area of maximum positive or maximum negative voltage, means for varying the location of said area along said member and synchronously along the two members of both units, and means coupling selected spaced points along said member of one unit with selected spaced points along said member of the other unit, said two units being related to provide a maximum voltage difference between the voltage distribution patterns on the two units at said areas, whereby a maximum voltage difference between the coupled spaced points is obtained between those coupled spaced points corresponding to the locations of said areas on the two members.

6. A network comprising first and second network units, each network unit comprising an impedance member, means for producing a voltage distribution pattern along said member having an area of maximum positive or maximum negative voltage, means for varying the location of said area along said member, and means coupling selected spaced points along said member of one unit with selected spaced points along said member of the other unit.

7. A network comprising first and second network units, each network unit comprising an impedance member having two terminals, means for coupling both said terminals to each other and to one side of a voltage source, distributed impedance means coupled to said member for coupling the other side of said source to spaced points on said member intermediate said terminals, and means coupling selected spaced points on said member of one unit with selected spaced points on said member of the other unit.

8. A network as set forth in claim 7, and further including means for varying the effective impedance midpoints of said network units.

9. A network as set forth in claim 8, wherein said effective impedance midpoint varying means comprises variable impedance means included in said means for coupling said terminals to each other and to one side of a voltage source.

10. A network as set forth in claim 9, wherein said impedance member is a resistance and said distributed impedance means comprises a plurality of electrically parallel resistances coupling spaced points on said member to said source.

11. A network comprising first and second network units, each network unit comprising an impedance member having two terminals, means for coupling both said terminals to each other and to one side of a voltage source, a plurality of electrically parallel impedance means coupled to spaced points along said member intermediate said terminals for coupling said points to the other side of said source, and means coupling selected spaced points on said member of one unit with selected spaced points on said member of the other unit.

12. A network as set forth in claim 11, wherein each of the last mentioned spaced points on said member of one unit substantially corresponds with the first mentioned spaced points on said member, and wherein each of the last mentioned spaced points on said member of the other unit is located substantially midway impedance-wise be-

tween two adjacent ones of the first mentioned spaced points on said member.

13. A network as set forth in claim 12, and further including means for varying the effective impedance midpoints of said network units.

14. A network as set forth in claim 13, wherein said effective impedance midpoint varying means comprises variable impedance means included in said means for coupling said terminals to each other and to one side of a voltage source.

15. A network as set forth in claim 14, wherein said impedance member is a resistance, and said plurality of electrically parallel impedance means are a plurality of resistances.

16. A network as set forth in claim 11, and further including a grid of substantially parallel conductors coupled to the last mentioned means.

17. A network as set forth in claim 11, and further including at least one output terminal coupled to the last mentioned means.

18. A network comprising first and second network units, each network unit comprising an elongate resistance



member having two terminals, means including a variable impedance means coupling said two terminals to each other and for coupling said two terminals to one side of a voltage source, a plurality of resistances coupled to spaced points along said member intermediate said terminals for coupling said points to the other side of said voltage source, and a plurality of resistance elements individually coupling said spaced points on the member of one unit with points on the member of the other unit located intermediate said spaced points thereon.

19. A network as set forth in claim 18, and further including a plurality of output taps coupled to the last mentioned resistance elements.

20. A network as set forth in claim 19, and further including a grid of a plurality of substantially parallel conductors each coupled to a corresponding one of said output taps.

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