

[72] Inventor **Max Epstein**
Highland Park, Ill.
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[73] Assignee **Northwestern University**
Evanston, Ill.

[56]

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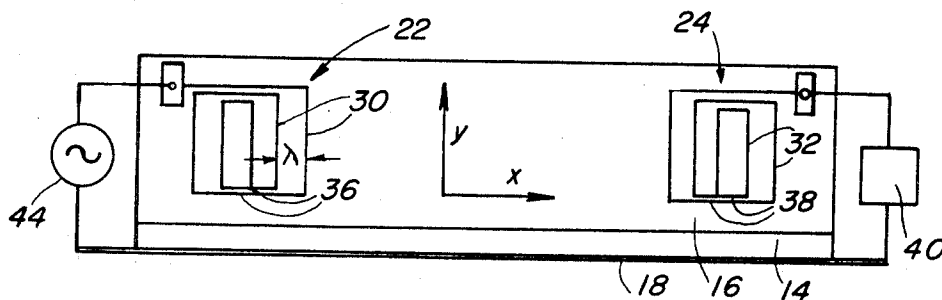
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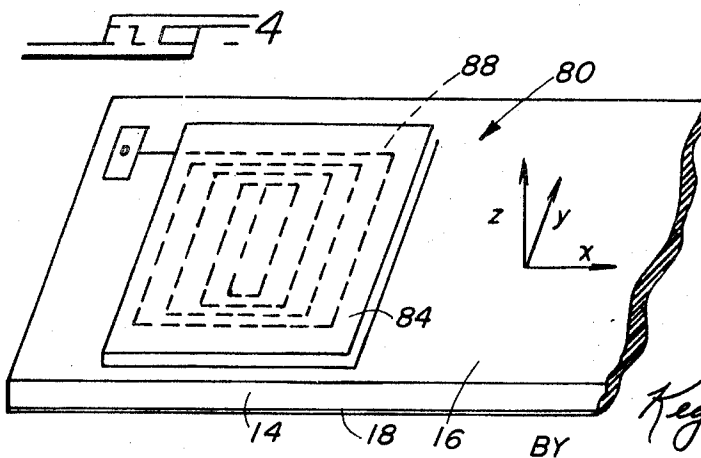
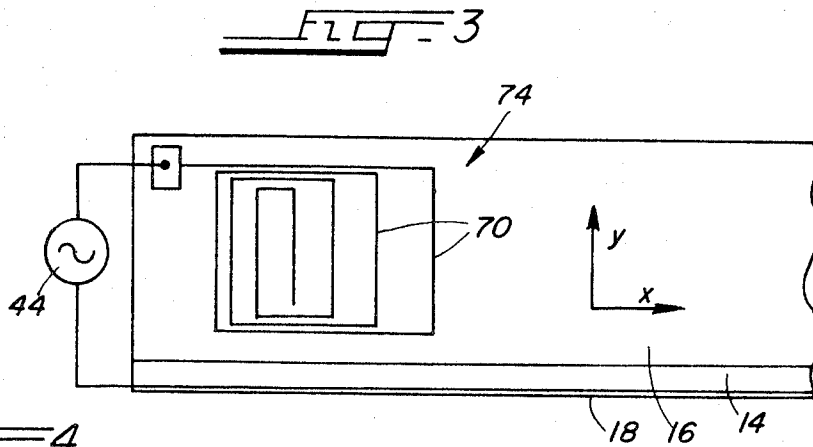
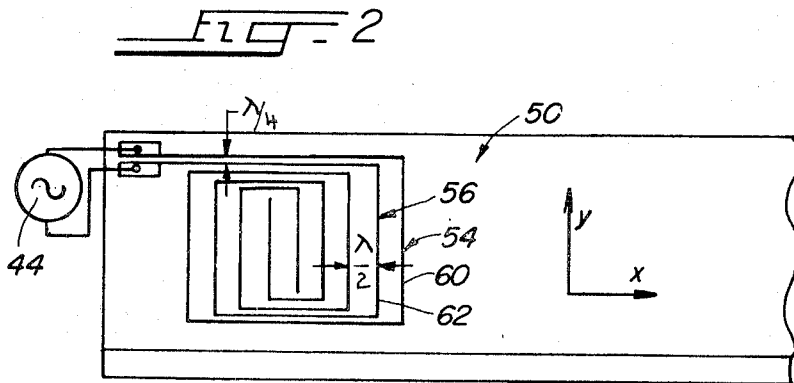
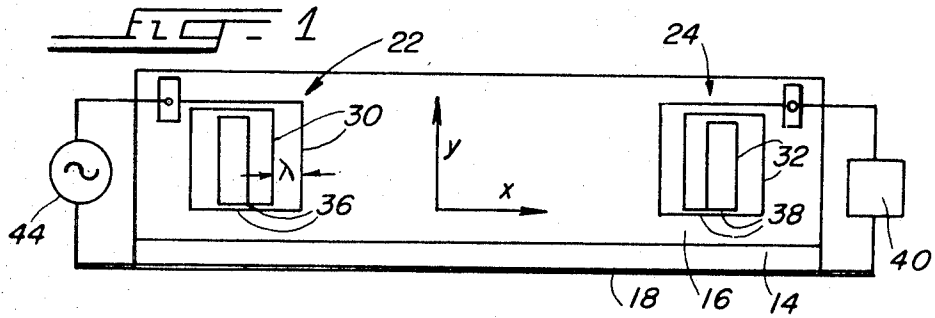
Primary Examiner—D. F. Duggan*Assistant Examiner*—B. A. Reynolds*Attorney*—Kegan, Kegan & Berkman

[54] **MICROACOUSTIC SURFACE-WAVE
TRANSDUCER**
11 Claims, 5 Drawing Figs.

[52] U.S. Cl. **310/8.2,**
310/9.7, 333/30, 333/72
[51] Int. Cl. **H01v 7/00**
[50] Field of Search. 310/9.7,
9.8, 8.2, 8.1, 8.3; 333/30, 72, 20

ABSTRACT: A surface-wave transducer, fulfilling in a single structure the requirements of both electric and acoustic matching. There is also disclosed a convenient technique for the transduction of signals having a wide frequency bandwidth. The transducer used can be produced utilizing simple photoetching techniques and may be employed at extremely high frequencies.

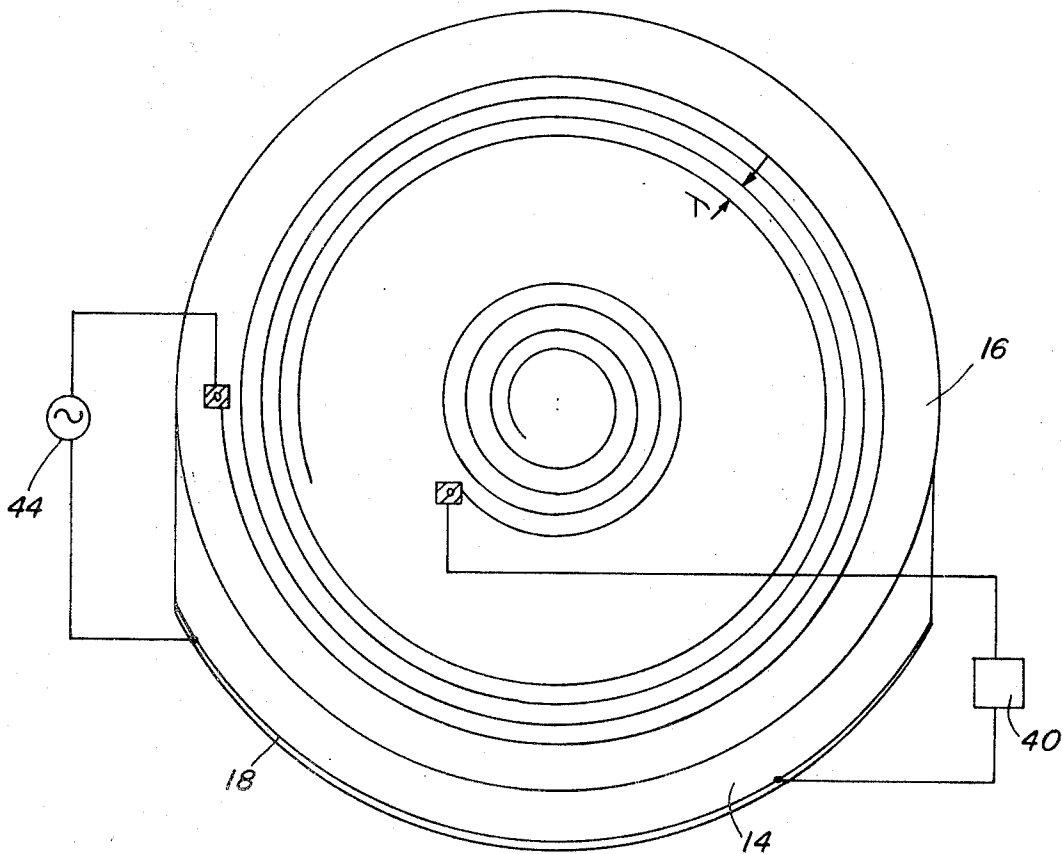




INVENTOR.
MAX EPSTEIN

Kegan, Kegan & Berkman
ATTYS

BY



INVENTOR.
MAX EPSTEIN

BY Kegan, Kegan & Berkman

77745.

MICROACOUSTIC SURFACE-WAVE TRANSDUCER

The present invention relates to apparatus and techniques for the transduction of electric signals to and from elastic wave structures.

Recent developments of elastic wave circuit devices of the type which utilize surface mode propagation have been employed in the design of amplifiers, modulators, detectors and filters through performance of the signal processing functions acoustically rather than electronically. The surface wave mode provides convenient access to the acoustic signal and is compatible with present integrated circuit technology. The trends indicated by such developments point to a new generation of miniaturized microwave devices.

One of the most efficient methods of transduction of signals into the surface wave acoustic mode is by means of an electroded structure deposited on a piezoelectric material which may also serve as the medium for the propagation of the acoustic wave. When utilized at high frequencies, such transducers are quite small and are best obtained by means of photoetching techniques as employed in other microelectronic devices.

In a preferred embodiment of the present invention, the transducer may consist of parallel electrodes spaced an acoustic wavelength apart with a conducting plate on the other side of the piezoelectric plate or film or, more frequently, an array of electrodes at alternately opposite potentials separated by half of the acoustic wavelength. Such an interdigitated transducer, as well as any other electroded structure, represents an electric capacity, and, in order to obtain an efficient transfer of energy between the electric and acoustic systems, usually requires a tuning inductance. Such an inductance, no matter how small, adds considerably to the size of the device and, in addition, by serving as a lumped parameter tuning element reduces the frequency bandwidth of the entire system. It is to the solution of this problem and related problems that the instant invention is directed.

In accordance with the practice of the subject invention, it has been established that the electroded transducer for an acoustic surface wave device can be obtained by forming rectangular spiral loops with appropriate spacing between the straight sections of the loops. Such a structure comprises a distributed network with parameters consisting of inductance, and capacitance, and resistance of each straight section of the spiral. In addition, the acoustic energy transfer in the transducer can be represented by a distributed load in the transmission line analogue of the device.

Further features, advantages, and aims of the invention will become apparent from a reading of the following specifications considered in conjunction with the drawings in which:

FIG. 1 illustrates a microacoustic surface wave transducer in accordance with the present invention;

FIG. 2 illustrates a structure similar to that of FIG. 1, but represents the equivalent of an interdigitated transducer;

FIG. 3 represents a transducer similar to that of FIG. 1 but having nonuniform spacing between the segments of the spirals of the acoustic wave generator;

FIG. 4 shows a transducer in accordance with the invention and similar to that illustrated in FIG. 1, with the addition of a ferrite plate; and

FIG. 5 illustrates, schematically, a microacoustic surface wave transducer utilizing materials with isotropic piezoelectric characteristics in the basal plane, and effective to suppress generation of surface acoustic waves in unwanted modes.

Referring more particularly to the drawings, FIG. 1 shows a microacoustic surface wave transducer 10 comprising a substrate 14 having a polished surface 16 and a metallic backing plate 18. Thin metallic elements 22 and 24, in the form of rectangular spirals, are deposited on the surface of the substrate 14 and constitute the sending and receiving transducers, respectively. The spacing between straight sections 30 and 32 of the respective electrode structures 22 and 24, in the direction of the acoustic wave (X) is equal to an acoustic wavelength. The spacing between the other straight portions 36 and 38 of respective electrodes 22 and 24 which elements

complete the rectangular spirals, are selected such that no acoustic surface wave is generated in the y direction. Several techniques may be utilized to ensure the desired operation. One such procedure is to make the spacing between the sections 36 and 38 small as compared with an acoustic wavelength. Preferably the spacing may be made equal to one-half of an acoustic wavelength. Proper selection of the substrate as to its anisotropy can also provide the desired suppression of waves in the y direction. It is within the concept of the present invention that the spacing in the y direction may be "eliminated" altogether by depositing the coil segments one on top of the other. The problem of suppressing the generation of surface acoustic waves from the straight portions 36 and 38 of the respective electrodes 22 and 24 can be eliminated in the case of materials with isotropic piezoelectric characteristics in the basal plane, such as ceramics (PZT, BaTiO₃, etc.) or proper cuts or deposition of CdS, ZnO. FIG. 5 illustrates such a microacoustic surface wave transducer, this concept applying to all of the other structures indicated subsequently.

With the structure as set forth above, the acoustic surface wave is obtained by connecting the input transducer or electrode coil 22 through a signal generator 44. The input and the output transducers 22 and 24 may be considered a distributed network which may be approximated by a transmission line analogue. In the form of the invention illustrated in FIG. 1, the "transmission line" appears open circuited. However, it must be recognized that the useful load of such a line, which represents the transfer of energy to the acoustic surface wave, is distributed along the structure. Hence, the optimum performance of a given transducer may determine the required termination of this distributed network. Any required or desired termination may be conveniently obtained by depositing a thin film resistor between the end of the spiral 22 and the backing plate 18, including a "short" if such should be desired.

The structure of FIG. 2 represents the equivalent of an interdigitated transducer 50. As illustrated, the device includes two spiral coils 54 and 56 wound in parallel with the X-spacing between adjacent segments 60 and 62 in the X-direction equal to one-half the acoustic wavelength. The signal is applied between the two coils 54 and 56. The considerations regarding the spacing in the y direction follow those previously discussed in connection with the transducer of FIG. 1. In the case of the interdigitated transducer of FIG. 2, the spacing in the y direction is conveniently one-fourth acoustic wavelength or one complete acoustic wavelength. In either of these cases, such spacing would essentially eliminate the generation of acoustic surface waves in the y direction. Again, the proposed structure of FIG. 5 can be also utilized in the case of the interdigitated transducer.

In the embodiment of the invention illustrated in FIG. 3, the spacing between the segments 70 of the rectangular spirals 74 which contribute to the generation of acoustic surface waves in the x direction are nonuniform. The structure depicted provides for the generation of elastic waves over a relatively wide frequency band. The variations in spacing may follow various forms including a logarithmic periodicity. The principles of the subject invention are particularly adaptable to the fabrication and design of surface wave transducers having variable periodicity.

Whereas transducers with uniform spacing result in devices operating over a small relative frequency bandwidth (high Q) such devices may be matched effectively to an electronic signal generator by means of a single lumped parameter inductance. However, the standard type transducer cannot be matched by a single inductor without sacrificing the wideband capabilities of the entire system. On the other hand, the transducer proposed in the subject invention is capable of operating over a wide frequency range by virtue of its distributed network characteristics. It should be noted that the problems of spacing in the y direction of such a wideband transducer become somewhat more complicated, and the elimination of

acoustic wave generation in the y direction more difficult. Here, again the structure depicted in FIG. 5 applies. It will be apparent that the arguments advanced in connection with the structure of FIG. 3 apply equally to an interdigitated transducer of the type described with reference to FIG. 2.

In applying the proposed transducers to the design of acoustic surface wave devices at lower frequencies, it may be found that the inductance obtained with the rectangular coil arrangement is not sufficiently large. FIG. 4 shows a transducer 80 similar to that depicted in FIG. 1 with the addition of a ferrite plate 84. The location of the plate with respect to the rectangular coil 88 is a variable which may be used to obtain the desired distributed inductance. The distributed capacitance to the transducer can also be varied by changing the thickness of the substrate 14 or the distance of the backplate 18 from the rectangular coil 88. The distributed inductance can also be modified by utilizing the spacing as in conductors 36 and 38 in FIG. 1. This can be done by inserting loops of wire either by deposition or by bonding.

The above considerations apply equally to interdigitated transducers.

While there have been described what are considered to be preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the invention, and it is intended that the appended claims cover all such modifications as fall within the spirit and scope of the invention.

What is claimed is:

1. A microacoustic surface wave transducer comprising a piezoelectric plate and a lumped parameter tuning element defining coupling means for matching said transducer to external circuitry associated therewith,

said coupling means comprising a spirally looped electrode supported on said piezoelectric plate, loops of said spirally looped electrode including interconnected first and second arrays of conductors, said first array consisting of spaced, straight, generally parallel, generally coplanar, conductive segments extending in a direction to carry an acoustic wave, spacing between adjacent said segments being correlated with a wavelength of the acoustic wave to facilitate reception and transmission thereof.

2. The structure as set forth in claim 1 wherein said second array consists of conductive elements extending generally normally of segments of said first array,

said conductive elements of said second array being spaced from one another a distance less than an acoustic wavelength to preclude generation, transmission, and reception of said acoustic wave thereby.

3. The structure as set forth in claim 1 wherein said second array of conductors extends generally normally of segments of said first array and in a plane generally perpendicular to a plane defined by said segments of said first array.

4. The structure as set forth in claim 1 wherein said coupling means comprises a pair of spiral coils wound in parallel, each said coils including a first array of parallel conducting

segments in which adjacent said segments are spaced an acoustic wavelength from each other, and

a second array of parallel conducting segments in which adjacent said segments are spaced one-half of an acoustic wave length apart.

5. The structure as set forth in claim 1 wherein said electrode comprises a generally rectangular spiral loop, said loop comprising a first array of conductive straight sections extending in a direction to transmit and to receive an acoustic wave impinging thereupon, said straight sections of said first array being spaced an acoustic wavelength from each other,

a second array of straight sections extending generally normally to said sections of said first array and being spaced from one another a distance to preclude reception of acoustic waves thereby and generation of acoustic waves therefrom.

6. The structure as set forth in claim 1 and further comprising means to regulate a distributed inductance parameter of said microwave transducer, and comprising a ferrite plate extending in a plane generally paralleling a plane defined by said spirally looped electrode and space therefrom.

7. The structure as set forth in claim 1 and further comprising means to regulate a distributed capacitance parameter of said microwave transducer, and comprising a substrate, said substrate constituting a support for said spirally looped electrode deposited thereon, variation of thickness of said substrate affecting a distributed capacitance parameter of said transducer.

8. The structure as set forth in claim 1 and further comprising a metallic backing plate spaced from and generally paralleling a plane defined by said spirally looped electrode, spatial separation of said electrode from said backing plate affecting a distributed capacitance parameter of said transducer.

9. The structure as set forth in claim 8 and further comprising a substrate interposed between said metallic backing plate and said electrode and constituting a support therefor.

10. The structure as set forth in claim 1 wherein said electrode comprises a generally rectangular spiral loop, said loop comprising:

a first array of spaced conductive straight sections extending in a direction to transmit and to receive an acoustic wave impinging thereupon, and

a second array of straight sections extending generally normally to said sections of said first array and being spaced from one another a distance to preclude reception of acoustic waves thereby and generally of acoustic waves therefrom,

spacing of said sections of said first array from each other being nonuniform from section to section, thereby to facilitate generation of elastic waves over wide-frequency bands.

11. The structure as set forth in claim 10 wherein said spacings of said sections of said first array follow a logarithmic periodicity.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,609,416

Dated September 28, 1971

Inventor(s) Max Epstein

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 22, "space" should read -- spaced --;
line 24, "disturbed" should read -- distributed --.

Signed and sealed this 29th day of August 1972.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents