Sept. 30, 1947. J. EVANS 2,428,272

TRANSMISSION LINE TRANSDUCER

Filed Nov. 8, 1944 3 Sheets-Sheet 1

Fig. 1.

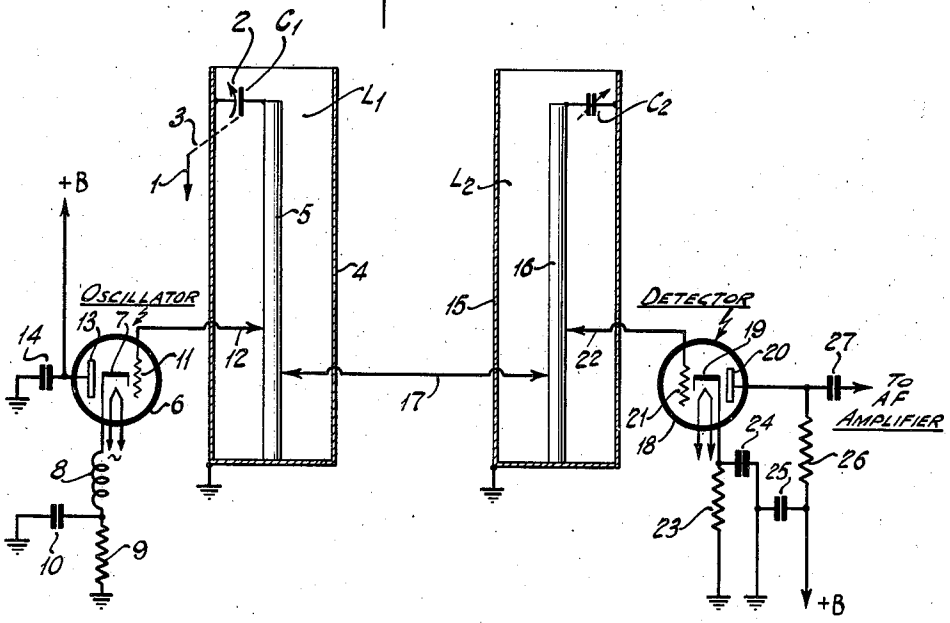
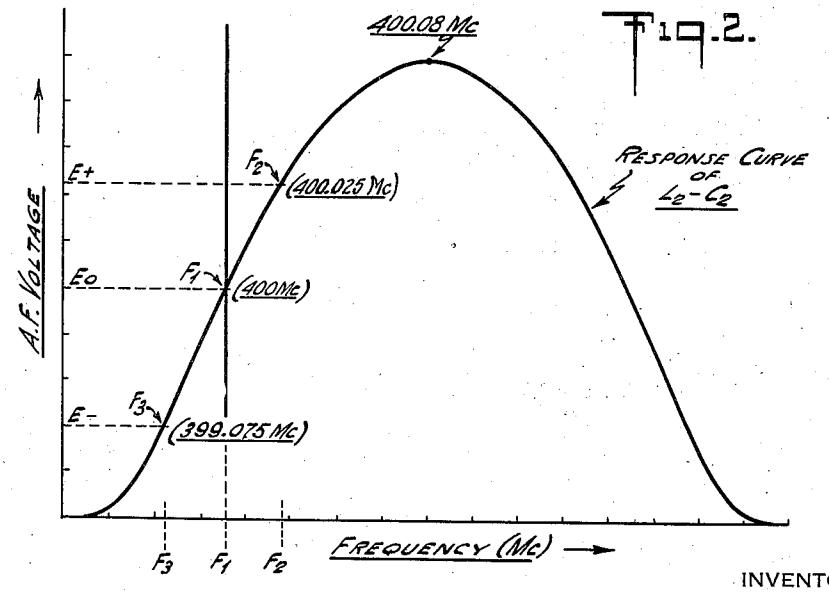


Fig. 2.



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Fig. 3.

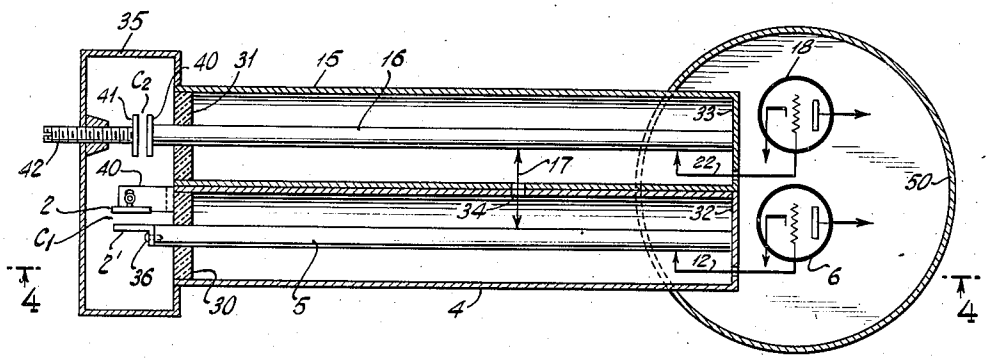


Fig. 4.

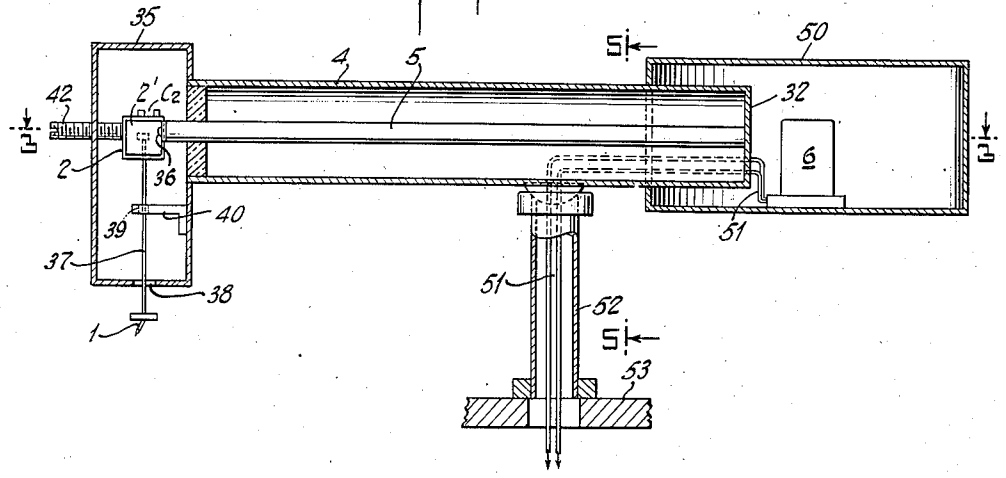
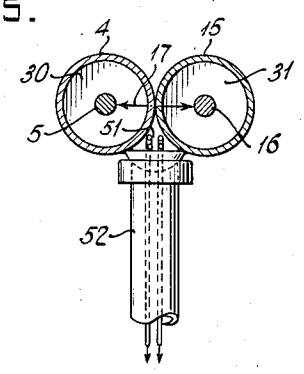


Fig. 5.



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Fig. 6.

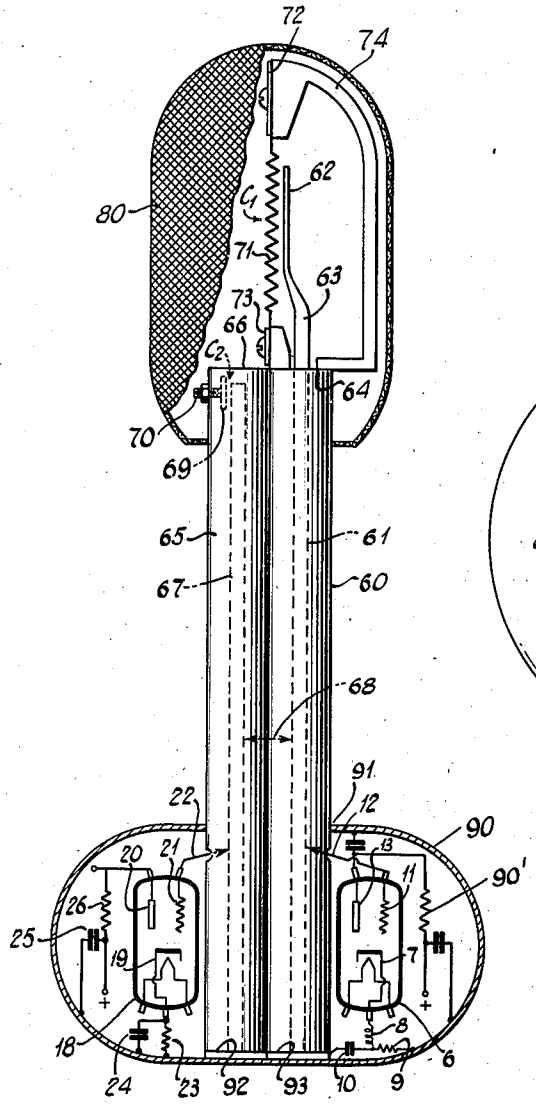
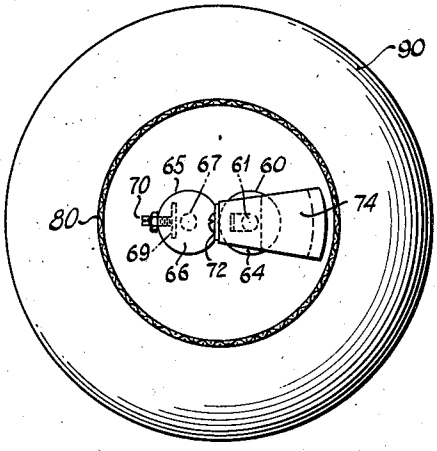


Fig. 7.



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UNITED STATES PATENT OFFICE

2,428,272

TRANSMISSION LINE TRANSDUCER

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Application November 8, 1944, Serial No. 562,551

18 Claims. (Cl. 179—100.4)

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My present invention relates generally to transducers, and more particularly to improved phonograph pickup units and microphone devices.

One of the main objects of my present invention is to provide a phonograph pickup unit which possesses a relatively low inertia, and which essentially comprises transmission line resonant circuits.

Another important object of my invention is to provide a frequency modulation (FM) microphone system utilizing transmission line circuits thereby permitting the conversion of sound energy to electrical energy over a wider frequency range than is possible with magnetic or pure capacitive devices.

Another important object of my invention is to provide a mechanical support, such as the tone arm of a pickup unit or the vertical support tube of a microphone, which has a double function in that it is constructed to act as a transmission line type of frequency discriminator.

Still another object of my invention is to provide a pair of concentric line resonators tuned to different, but closely adjacent, frequencies; one of the resonators functioning as the tank circuit of an ultra-high frequency oscillator, the other resonator acting as a discriminator for frequency modulated oscillations created by virtue of frequency change of the tank resonator in response to variations of the reactive element of a transducer.

Another object of my invention is to provide a pair of concentric line resonators each functioning as a tuned circuit of a transducer system, the resonators additionally acting as the mechanical support of a variable element of the transducer.

Yet another object of my present invention is to provide an FM phonograph pickup unit which is self-contained but minus the filament and anode current supplies, permitting its use with present record reproducers with no major changes in the existing amplifier circuits.

Still other objects of my present invention are to improve generally the simplicity and efficiency of phonograph pickup units and microphones, and more especially to provide frequency modulation transducer systems which are not only reliable in operation but are economically manufactured and assembled.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by

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reference to the following description, taken in connection with the drawing, in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings:

Fig. 1 is a circuit diagram of a phonograph pickup system constructed in accordance with my invention;

Fig. 2 shows the frequency response curve of the discriminator circuit of the system of Fig. 1;

Fig. 3 is a plan view, partly in section, of a tone arm constructed in accordance with my present invention;

Fig. 4 is a sectional view of the tone arm taken along line 4—4 of Fig. 3 looking in the direction of the arrows;

Fig. 5 is a sectional view of the tone arm taken along the line 5—5 of Fig. 4 looking in the direction of the arrows;

Fig. 6 is a partially schematic view in elevation of a microphone constructed in accordance with my invention; and

Fig. 7 is a plan view of the microphone system shown in Fig. 6.

Referring now to the accompanying drawings, wherein like reference numerals in the various figures indicate similar circuit elements, I have shown in Fig. 1 the fundamental circuit of my improved system for translating reactance changes into electrical currents representative of such changes. While the specific reactive device shown in Fig. 1 is a condenser including a stylus-actuated electrode, it is to be clearly understood that my invention is not restricted to a stylus for actuation of the adjustable electrode, nor to a condensive reactance. Generally speaking, my system may be employed wherever a physical force is to be indicated or represented, and where the force may be employed to displace the mobile element of the reactive device thereby to vary the frequency of the associated oscillator. Such frequency variations may then be detected, and the detected currents indicated in any desired manner.

In the circuit of Fig. 1 the numeral 1 denotes the stylus of a phonograph pickup unit. The stylus or needle 1 may be mechanically coupled in any suitable manner to the mobile electrode 2 of a condenser C_1. The dotted line 3 is to be understood as representative of any suitable coupling which will cause displacements of electrode 2 in response to motion of the stylus 1. For example, and merely to illustrate my system, the stylus point could be riding through the

grooves of a phonograph record mounted on a suitable turntable (not shown to preserve simplicity of disclosure).

The condenser C_1 is electrically associated with an inductance L_1 of the general form of a concentric line resonator. Those skilled in the art of ultra-high frequency communication are fully aware of the construction and design of such a line. Briefly, the line consists of a metal tube, shell or cylinder 4 which is at ground potential. The shell is provided with a concentric, axially-located metal rod 5 which is also at ground potential. The condenser C_1 is connected between the upper ends of shell 4 and rod 5. Hence, the variable condenser provides a means for adjusting the frequency of the transmission line resonant circuit L_1C_1. Obviously, displacements of stylus 1 will result in corresponding variations of the capacitance of condenser C_1. The frequency of concentric line resonator L_1C_1 will be varied in accordance with the capacitance variations of C_1.

Preferably the effective electrical length of resonator L_1 is chosen to be one quarter of the normal operating wavelength. Such an electrical length provides an inherently stable circuit. Further, the impedance along the concentric line resonator L_1 is zero at the ground end, and increases to a maximum to the point where the stylus 1 is affixed. This is a practical advantage, since small stylus displacements will effect large impedance changes. Hence, the stylus and associated condenser may be constructed of very light material, and in effect provide a low inertia pick-up unit. It is assumed, merely by way of specific explanation and illustration, that the normal or operating frequency of resonator L_1C_1 is 400 megacycles (mc.). It is to be clearly understood that the normal frequency of L_1C_1 can be chosen from a wide range of ultra-high frequencies, e. g., 200 to 500 mc. The choice of operating frequency will depend upon the physical length of shell 4 desired. At 300 mc., for example, the electrical length of the inner conductor or rod 5 would be one fourth of a meter, or 9.9 inches. The physical length of the shell 4 could be made longer than the latter length without affecting the electrical length by having the end of shell 4 project a predetermined distance beyond the end of conductor 5. The concentric line resonator functions as the tank circuit of an oscillator.

The oscillator tube 6 is preferably one of the miniature type; i. e., the so-called acorn type. It is desirable to use a tube of relatively high amplification factor. The indirectly-heated cathode 7, which may be of the filament type if desired, is connected to ground through coil 8 and grid bias resistor 9 arranged in series. The condenser 10 bypasses resistor 9 to ground, and establishes the lower end of cathode coil 8 at ground potential for radio frequency currents. The control grid 11 is connected by lead 12 to a suitable point on inner conductor rod 5 such that the input impedance of the tube matches the impedance of the line resonator between the tapping point and ground. The plate 13 is connected to a direct current potential point +B of suitable positive value; plate 13 is connected to ground by condenser 14 for radio frequency currents.

The oscillations are produced at the normal frequency of the concentric line tank circuit L_1C_1. It will be noted that the plate is at ground potential as respects radio frequency potentials, and that radio frequency voltage developed across cathode coil 8 is fed back to the tank circuit of tube 6. The oscillations thus produced are of relatively high amplitude, and are stable as to frequency by virtue of the degenerative effect on the cathode coil 8 of the grounded plate. The ultra-high frequency oscillations may be produced in any other way; I desire to make it clear that there may be used any other specific method of producing stabilized oscillations. The outer shell 4 being grounded inherently functions as a shield. It is desirable to use for the material thereof a metal of high electrical conductivity and low loss. For example, a fibrous shell could be employed with metal coatings provided over the inner and outer surfaces thereof. Such a shell would have a low inertia in addition to the above characteristics. The inner conductor 5 could be similarly constructed.

The oscillatory output of tank circuit L_1C_1 is frequency modulated (FM), since the variations in capacitance of condenser C_1 cause variations in the frequency of the tank circuit. The extent of frequency variation or deviation of F_1, the stable normal oscillator frequency, depends on the amplitude of the stylus displacement. Since the latter is responsive to the grooves of a sound record, it follows that the audio frequency amplitude determines the extent of frequency swings of the circuit L_1C_1. The rate of frequency deviation is a function of the audio frequencies per se. I use the generic term "angle modulated" to denote the fact that the modulation of the oscillator output may be either in frequency or phase. The overall maximum frequency swing of the FM oscillations is dependent on the L/C ratio of the tank circuit, and can be as wide as 50 kilocycles (kc.).

The FM oscillations are detected by a discriminator-rectifier network comprising a second concentric line resonator which is coupled to the tank circuit L_1C_1. The latter feeds amplitude modulated oscillations to a detector tube. The second resonator consists of an outer metal shell 15 whose lower end is grounded. The second concentric resonator has an electrical length such that inductance L_2 of the resonator tunes with condenser C_2 to a frequency higher or lower than the normal oscillating frequency. The discriminator circuit L_2C_2, in the form of the concentric line resonator, may be constructed in the same manner as resonator L_1C_1, except that the condenser C_2 would be adjusted so as to have the frequency of L_2C_2 suitably different from that of L_1C_1. The line 17 couples suitable points on the inner conductors 5 and 16 so as to match the impedances of the tuned circuits. Once chosen, the magnitude of C_2 is not changed in the particular unit, except for servicing of the latter.

The detector tube 18 may be a miniature type triode of the same type as tube 6. Indirectly-heated cathode 19 is connected to ground by grid bias resistor 23, bypassed to ground for radio frequencies by condenser 24. Grid 21 is connected by coupling lead 22 to a suitable point on conductor 16 such that the input impedance of tube 18 matches the tapped section of the input circuit. The plate 20 is connected to the +B voltage point of a suitable direct current source through load resistor 26 whose magnitude may be about 50,000 ohms, the lower end of the load being bypassed to ground by condenser 25. The modulation frequency, audio in the case of records, voltage is transmitted through coupling

condenser 27 to any suitable audio frequency amplifier circuit.

The curve in Fig. 2 shows the form of response curve desired for discriminator circuit L_2C_2. The curve was secured by plotting "frequency" in megacycles as abscissae against "A. F. voltage" produced across resistor 26 as ordinates. The peak frequency of the curve in Fig. 2 is the normal resonant frequency of the circuit L_2C_2. The physical lengths of outer shells 4 and 15 will be the same, but the electrical lengths of the two resonators will be sufficiently different to provide the frequency displacement specified. The normal oscillator frequency F_1 will be selected so as to fall at the midpoint of a linear portion of one of the flanks of the response curve. For example, the peak frequency of circuit L_2C_2 may be 400.08 mc., and the normal oscillator frequency F_1 may be located at 400 mc. The extreme ends of the frequency swing F_2 and F_3 would then be 400.025 mc. and 399.075 mc. respectively, assuming an overall frequency of 50 kc.

The FM oscillations applied to circuit L_2C_2 will develop corresponding amplitude-variable energy by virtue of the sloping flank of the response curve. The variable amplitude energy will be detected by detector tube 18, since the resistor 23 provides sufficient grid bias to permit the tube to act as a detector of the plate rectification type. The output voltage across resistor 26 will vary between extreme values of E+ and E— corresponding to frequency extremes F_2 and F_3 respectively. Of course, the invention is not restricted to the specific frequencies mentioned. Furthermore, the oscillator frequency F_1 could be located at a similar midpoint on the opposite flank of the response curve in Fig. 2. In general, if one of the two circuits L_1C_1 or L_2C_2 has an electrical length of ¼ of a wavelength, the other circuit would have an electrical wavelength a suitable amount plus or minus different therefrom.

In Figs. 3, 4 and 5 I have shown an embodiment of a tone arm and pickup unit constructed in accordance with my invention. The outer metal shells 4 and 15 of the oscillator tank circuit and discriminator circuit respectively are each in the form of horizontal cylinders. The left ends of the shells 4 and 15 are provided with dielectric closures 30 and 31 respectively. The right ends of the shells 4 and 15 are provided with metallic closures 32 and 33. As shown in Figs. 3 and 5 the shells 4 and 15 are in direct contact, a common opening 34 being provided in the shell walls at a predetermined point along the line of contact of the shells. The coupling conductor 17 passes through opening 34 so as electrically to connect the inner conductors 5 and 16.

The inner conductors 5 and 16 are in conductive contact with closures 32 and 33 respectively at the centers thereof. They may be secured thereto by soldering, or by any suitable means for providing a secure and rigid joint. The opposite ends of conductors 5 and 16 pass through the centers of the respective insulation closures 30 and 31 into a head, or forward casing, housing the electrodes of condensers C_1 and C_2. If desired, the coupling between the two resonators may be field coupling. By removing conductor 17 and replacing opening 34 by an extensive slot common to both shells, such field coupling is readily provided.

Condenser C_1 consists of the mobile electrode, or plate, 2 and stator or fixed electrode 2'. The stator electrode 2' is secured to the left end of conductor 5 extending into the interior of casing 35. The latter has a generally rectangular cross-section, and is preferably composed of the same metallic material as shells 4 and 15. The electrode 2' is preferably provided with a flange 36 so as to permit ready affixing to the end of conductor 5. The flange 36 may be soldered or bolted to the conductor 5. The mobile electrode 2 is secured to the upper end of a pivoted vertical rod 37 whose lower end is provided with stylus 1. The casing 35 is provided with a slot 38 through which the lower end of rod 37 passes.

The slot 38 permits motion of the rod 37, in response to displacement of stylus 1 due to scanning the record grooves, relative to pivot point 39. The latter may be provided by a support arm 40 whose free end acts as a bearing for the rod 37. The displacements of stylus 1 are translated into motion of mobile electrode 2 with respect to stator 2'. It is to be clearly understood that this construction of the variable condenser C_1 and its mechanical coupling to stylus 1 is purely illustrative. Any other suitable construction may be employed to translate motion of the stylus into corresponding variable capacitance of a condenser.

The fixed condenser C_2 consists of a pair of electrodes or metal discs 40 and 41. The electrode 40 is rigidly secured to the end of conductor 16. The electrode 41 is normally spaced from the electrode 40 by a predetermined distance. To permit factory adjustment, or service adjustment, the disc 41 may be affixed to the inner end of a threaded stem 42 whose exposed head is provided with an adjustment slot. In this way the capacitance of C_2 may be adjusted easily and simply in order to secure a desired and suitable peak frequency for discriminator circuit L_2C_2.

The condensers C_1 and C_2 are completely housed within the shielding casing 35. The latter is in conductive contact with shells 4 and 15 whereby the inductive and capacitative elements of both tank and discriminator circuits are shielded from external interference. The pickup unit, the tank and discriminator circuits are, moreover, a common mechanical system wherein the shells of the concentric resonators function as mechanical supports for the pickup unit. The tubes 6 and 18 are housed within a metallic casing 50 of circular cross-section. The casing 50 is snugly fitted over the right ends of shells 4 and 15. The opening of casing 50 should conform to the circular configuration of shells 4 and 15 as closely as possible.

In Fig. 3 these two tubes are schematically represented, the grid leads 12 and 22 from respective tubes 6 and 18 to respective conductors 5 and 16 being shown. The grid leads 12 and 22 are passed through suitable bores in the closure discs 32 and 33 respectively. The current leads to the tubes are not shown in Fig. 3. However, Fig. 4 shows the manner of mounting the physical tubes (tube 6 specifically) on the base of casing 50. The energizing current leads 51 are shown in Figs. 4 and 5. It will be seen that the power leads to the filament and plate are run up through the interior of metallic support post 52 which is secured to any suitable chassis 53.

The metallic support post 52 is hollow, and is grounded by virtue of its rigid coupling to metallic chassis 53. The horizontal shells 4 and 15 may be secured to the upper end of post 52 in any desired fashion as by soldering, welding and the like. From Fig. 5 it is seen that the upper end of support post 52 provides a fulcrum point for the tone arm. Briefly, it is de-

sired to couple the tone arm to the support post in such a manner as to permit suitable motion of the tone arm during record reproduction. Those skilled in the art of constructing phonograph tone arms will readily be aware of any suitable means for providing a universal coupling joint between the tone arm unit and the support post 52. For this reason the mechanical details of the tone arm support post are not shown.

The energizing current leads 51 are passed through the top opening of post 52, and then along the space underneath the line of contact between shells 5 and 15. It will be understood that the lower lip of the forward opening of casing 50 will be constructed so as to permit the leads 51 to be run into the interior of casing 50, but along the space adjoining the line of contact of the rear ends of shells 50 and 15. It is not believed necessary to show the detailed construction of the bases for receiving the prongs of tubes 6 and 18. It will be realized that the outer shells 4 and 15 of the concentric resonators are at ground potential by virtue of the metallic connection between the vertical support post 52 and the pair of shells. Furthermore, the casings 35 and 50, being in metallic contact with the grounded shells, are also at ground potential. In this way the entire unit functions as a shield for the circuit elements located within the interior of the front and rear casings and the shells. It will, therefore, be seen that I have provided a transmission line phonograph pickup unit which is of low inertia. Further, there is provided a self-contained unit functioning simultaneously as a mechanical tone arm and a pair of electrical circuits, while additionally including a section adapted to carry or support the oscillator and detector tubes.

In Figs. 6 and 7 I have shown an embodiment of the invention which is essentially a transmission line microphone. In this case certain of the elements in Fig. 6 are schematically represented, while other of the elements are shown in constructional form. Still other elements are shown in section in order clearly to reveal the mechanical structure of the device. In this modification of the invention the electrical circuits involved are substantially the same as in Fig. 1, except for the fact that the condenser C_1 is a voice-actuated condenser microphone.

The oscillator circuit in the case of Fig. 6 comprises the vertical concentric line resonator consisting of the outer shell 60 and the inner conductor 61. The upper end of the inner conductor 61 terminates in the form of the fixed plate 62 of the condenser microphone. The latter is represented by the symbol C_1, because it is analogous in function to the stylus-actuated condenser C_1 in Fig. 1. The electrode 62 is maintained in vertical fixed position by virtue of the offset coupling 63 to the upper end of inner conductor 61. As a matter of actual mechanical construction the inner conductor 61 may have the sections 63 and 62 integral therewith, but it is to be understood that the top end of shell 60 is closed by the closure disc 64. The inner conductor passes through the center thereof to provide the offset section 63.

The second concentric line resonator comprises the vertical outer shell 65 whose physical length is the same as the physical length of shell 60, and whose upper end is similarly closed by metallic disc 66. The shell 65 is provided with the axial inner conductor 67. The shells 65 and 60 are in metallic contact along the entire lengths thereof. The inner conductors 67 and 61 are electrically coupled by the direct connection 68 therebetween. It will be understood that the electrical connection 68 is provided through common openings in the contacting surfaces of the shells, as shown in Fig. 3 for the conductor 17.

The condenser C_2, which is analogous in function to the condenser C_2 in Figs. 1 and 3, is provided in this modification by utilizing the upper end of inner conductor 67 as one electrode of the condenser. The adjustable second electrode of condenser C_2 is provided by means of a metallic disc located within the upper end of shell 65 in spaced relation from the end of conductor 67. The numeral 69 indicates the adjustable electrode, and it will be observed that electrode 69 is provided with a threaded stem 70 having a slotted head so as to permit ready adjustment of the space between electrode 69 and the electrode which is provided by the adjacent upper end of conductor 67.

It will be noted that the upper end of conductor 67 terminates in spaced relation from the closure 66, and that the threaded stem 70 protrudes from the shell 65. The mobile or displaceable electrode of condenser C_1 is provided by a ribbon 71 (schematically portrayed) of suitable metallic material. For example, such material could be duraluminum, although the invention is not limited in any way to such material. Those skilled in the art of constructing microphones are fully aware of the manner of constructing a condenser microphone of the type generally represented herein by C_1 of Fig. 6. The normal spacing between electrodes 71 and 62 is chosen so as to provide a normal oscillator frequency which is located on a linear portion of one of the flanks of the resonance curve of the discriminator circuit. This is indicated in Fig. 2, and it is to be understood that the explanation given in connection with Fig. 2 applies equally well to the microphone circuits of Fig. 6.

The ribbon electrode 71 has its opposite ends securely clamped between the clamps indicated generally by numerals 72 and 73 respectively. Clamp 72 is shown consisting of an arm 74 whose lower end is rigidly secured in any suitable manner to the closure disc 64 of shell 60. The upper end of arm 74 is located above the upper end of electrode 62. The upper end of ribbon electrode 71 is clamped securely in place between the clamping faces at the upper end of arm 74. The lower end of ribbon electrode 71 is securely clamped between the clamping faces of clamp 73 which is supported on the closure disc 64. It will, therefore, be seen that electrode 71 is in conductive connection with the grounded shell 60, and that electrode 62, spaced from electrode 71, is also in conductive connection with the grounded shell 60. Obviously when sound waves impinge on the electrode 71 it will have a sufficiently low inertia so as readily to move with respect to electrode 62 thereby changing the frequency of the resonant tank circuit of the oscillator. The resonant frequency of the discriminator circuit does not change, because the capacity of condenser C_2 once predetermined and set is not changed during operation.

In Fig. 6 I have shown the protective grille 80 surrounding the entire microphone unit and the upper portions of the concentric line resonators. The protective grille 80 is partly broken away in Fig. 6. It will be understood that the grille 80 is of suitable construction customarily employed in velocity microphones, and it is not

believed necessary to show the grille 80 in any further mechanical detail. In Fig. 7 the grille 80 has been entirely cut through so as to show the details of the concentric line resonators. In Fig. 7 the numeral 90 indicates the base or supporting casing which houses the pair of oscillator and detector tubes and the high frequency connections thereto.

The base casing or pot 90 is composed of a metallic material, and its upper surface will be provided with an opening through which shells 65 and 60 pass. The opening 91 will, of course, be shaped so as to conform to the configurations of both shells. Preferably the bottom closure discs 92 and 93 of the respective shells are in direct contact with the bottom of pot 90, it being desirable to solder or otherwise fixedly secure the shells to the bottom section.

Tubes 6 and 18 are the respective oscillator and detector tube, exactly as in the embodiment of Fig. 1. The tubes are schematically represented in Fig. 6; the connections thereto are also schematically shown. However, it will be understood that the connections from tubes 6 and 18 to the inner conductors 61 and 67 are the same as shown in Fig. 1, and the various circuit components associated with tubes 6 and 18 are the same as in Fig. 1. Hence, the connections and circuit components in Fig. 6 are not described in detail, but are generally related by corresponding reference numerals to Fig. 1.

The grids 11 and 21 are connected by respective connections 12 and 22 to the respective inner conductors 61 and 67. The connections 12 and 22 pass through respective openings provided in the sections of shells 60 and 65 located within the pot 90. The connection points of leads 12, 22 and 68 to the inner conductors 61 and 67 will depend on the circuit impedances to be matched. The output load resistor 26 is in the plate circuit of tube 18, and it will be understood that pot 90, as well as shells 65, 60 and protective grille 80, will be at ground potential. The oscillator tube 6 includes coil 8 in its cathode circuit in series with grid bias resistor 9 to ground, condenser 10 bypassing resistor 9 to ground. The resistor 90' in the plate circuit of tube 6 is a hum filter. The energizing connections to the tube elements of the oscillator and detector tubes are indicated.

The microphone system of Fig. 6 operates very much the same as the record reproducer system of Fig. 1. The concentric line resonator 60, 61 is tuned by suitable spacing of electrodes 71 and 62 (condenser C_1) to the normal oscillator frequency F_1. Reference is again made to the resonance curve of Fig. 2 to illustrate that the oscillator frequency F_1 of Fig. 6 will be set to fall at the middle of the linear section of a flank of the discriminator circuit resonance curve. The concentric line resonator 65, 67 is tuned by proper adjustment of electrode 69 to the desired peak frequency of the resonance curve. The frequency values suggested in Fig. 2 may be employed.

Variation of the spacing between electrodes 71 and 62 of C_1 will cause similar variations in the frequency of the oscillator tank circuit. Voice waves will vary the capacitance of C_1 in accordance with the modulation of the waves, and the oscillator frequency will vary in accordance with the voice waves. The frequency variations between limits of F_2 and F_3, as explained in connection with Fig. 2, will result in corresponding variable amplitude high frequency waves being applied to detector grid 21. The detected audio voltage across resistor 26 may then be suitably amplified and reproduced. It will be observed that the outer metallic surfaces of the microphone system of Fig. 6 are at ground potential. Hence, they function as a suitable shielding means. Again, the oscillator tank and discriminator circuits function as the mechanical support means for the condenser microphone elements.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention.

What I claim is:

1. In a transducer system, a pair of electrically coupled concentric line resonators normally tuned to adjacent frequencies, means directly coupling the inner conductors of said resonators, one of said resonators including a condenser having a mobile electrode subject to physical displacements to be indicated, an oscillator tube including said one resonator as the tank circuit thereof, and a detector tube including the second resonator as the input circuit thereof.

2. In combination, a pair of coupled concentric line resonators tuned to different frequencies located on the resonance curve of one of the resonators, said resonators being in contact along the lengths thereof, an adjustable reactance device electrically connected with one resonator at one end thereof to vary the frequency thereof at an audio rate, and detector means coupled to the second resonator for indicating said frequency variations.

3. In a phonograph system, a tone arm consisting solely of a pair of coupled concentric line resonators tuned to respective frequencies separated by a predetermined frequency value, a variable condenser pickup electrically connected to one resonator, one of said resonators having an electrical length which is substantially a quarter wavelength long at the operating frequency, an oscillator tube including one of said resonators as the tank circuit thereof, and a detector tube including the second resonator as the input circuit thereof.

4. A microphone system comprising a pair of coupled concentric line resonators in contact along the lengths thereof, said resonators being tuned to closely adjacent different frequencies, one resonator having an electrical length which is a quarter wavelength long at the operating frequency, a condenser including a mobile electrode mounted at the top end of one resonator, and respective oscillator and detector tubes for said two resonators, and a shielding casing for said tubes at the lower ends of said resonators.

5. In a record reproducing system, an ultra-high frequency oscillator including a concentric line tank circuit, means including a stylus-responsive element for varying the frequency of the tank circuit, a detector having a concentric line resonator input circuit, a lead directly coupling the inner conductors of the two resonators, and means tuning said input circuit to a frequency differing from the normal frequency of the tank circuit by an amount such as to permit the input circuit to act as a frequency discriminator.

6. In combination, a high frequency oscillator

system including a concentric line resonator as a tank circuit, a condenser for tuning said tank circuit to a predetermined normal high frequency, said condenser having a mobile electrode, a detector including a second concentric line resonator acting as an input circuit, means directly coupling the inner conductors of said resonators, and means for tuning said second resonator to a predetermined frequency such that said normal oscillator frequency falls at an intermediate point of the flank of the resonance curve of said detector input circuit.

7. In combination, a high frequency oscillator system including a concentric line resonator as a tank circuit, a condenser for tuning said tank circuit to a predetermined normal high frequency, said condenser having a mobile electrode, a detector including a second concentric line resonator acting as an input circuit, means directly coupling said resonators, means for tuning said second resonator to a predetermined frequency such that said normal oscillator frequency falls at an intermediate point of the flank of the resonance curve of said detector input circuit, said resonators each comprising a metallic shell, said shells being in direct contact, and each shell having a respective axially-located inner conductor rod, said direct coupling means being connected between suitable points of said inner rods.

8. In combination, a high frequency oscillator system including a concentric line resonator as a tank circuit, a condenser for tuning said tank circuit to a desired high frequency, said condenser having a mobile electrode, a detector including a second concentric line resonator acting as an input circuit, means electrically coupling said resonators, means for tuning said second resonator to frequency such that said normal oscillator frequency falls at an intermediate point of the flank of the resonance curve of said detector input circuit, one resonator having an electrical length of one quarter wavelength at the operating frequency thereof, and said oscillator resonator including a metal shell whereby it functions as a mechanical support for said condenser.

9. In a record reproducer system, a pair of concentric line resonators, each resonator comprising an outer metal shell and an axially-located inner conductor rod, respective tuning condensers connected between the inner rod and outer shell of each resonator, said condensers tuning the resonators to adjacent high frequencies, one resonator being electrically a quarter wavelength long, one of said condensers including a stylus-actuated electrode, and means directly connecting said inner rods.

10. A phonograph tone arm comprising a pair of concentric line resonators of substantially equal physical length and in contact along the entire lengths thereof, the effective electrical length of one resonator being a quarter wavelength at the operating frequency, and the electrical length of the second resonator being such that the resonant frequency thereof is different from that of the one resonator, and a variable reactance pickup electrically connected to one resonator.

11. In a microphone system, a pair of electrically coupled concentric line resonators tuned to closely adjacent frequencies, a short lead directly coupling the inner conductors of said resonators, one of said resonators including a reactance having a mobile electrode subject to physical displacements to be indicated, an oscillator including said one resonator as the tank circuit thereof, and a detector including the second resonator as the input circuit thereof.

12. In combination, in a record reproducer, a pair of coupled concentric line resonators tuned to different frequencies located on the resonance curve of one of the resonators, an adjustable condenser device electrically connected with one resonator to vary the frequency thereof, said resonators being in direct contact and concurrently acting as the tone arm, and detector means coupled to the second resonator for deriving audio signals from said frequency variations.

13. In a record reproducer system, a tone arm consisting of a pair of rigid elongated concentric line resonators tuned to respective frequencies separated by a predetermined frequency value and in direct contact, said resonators each having an effective electrical length which is substantially a quarter wavelength, and a reactance pickup device coupled to one resonator.

14. In a record reproducing system, a high frequency oscillator including a concentric line tank circuit, means including a stylus-responsive element for varying the frequency of the tank circuit to produce frequency modulated oscillations, a detector having a concentric line resonator input circuit coupled to said oscillator, a short lead directly coupling the inner conductors of said concentric line resonators, and means tuning said input circuit to a frequency differing from the normal frequency of the tank circuit by an amount such as to permit the input circuit to act as a frequency discriminator.

15. In combination, a high frequency oscillator system including a concentric line resonator as a tank circuit, a condenser for tuning said tank circuit to a desired frequency, said condenser having an adjustable electrode, a detector including a second concentric line resonator acting as an input circuit, means coupling the inner conductors of said resonators, and means for tuning said second resonator to a frequency such that said oscillator frequency falls at an intermediate point of a linear section of the flank of the resonance curve of said detector input circuit.

16. In a microphone system, a pair of electrically coupled rigid and elongated transmission line resonators tuned to closely adjacent frequencies and in direct contact along the lengths thereof, one of said resonators including a reactance having a mobile ribbon electrode, an oscillator tube including said one resonator as the tank circuit thereof, and a detector tube including the second resonator as the frequency discriminator input circuit thereof.

17. In combination, a pair of directly coupled transmission line resonant circuits tuned to different frequencies located on the resonance curve of one of the resonant circuits, an adjustable reactance device electrically connected with one resonant circuit to vary the frequency thereof, an oscillator including said one resonant circuit as the tank circuit thereof, and means coupled to the second resonant circuit for indicating said frequency variations.

18. In a transducer system, a support arm consisting solely of a pair of rigid elongated transmission line circuits tuned to respective frequencies separated by a predetermined small frequency value, said transmission lines being in direct contact, one of said circuits having an effective electrical length which is substantially

a quarter wavelength at the operating frequency, and a variable reactance pickup connected to one of the elongated transmission line circuits.

JOHN EVANS.

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