

Oct. 22, 1929.

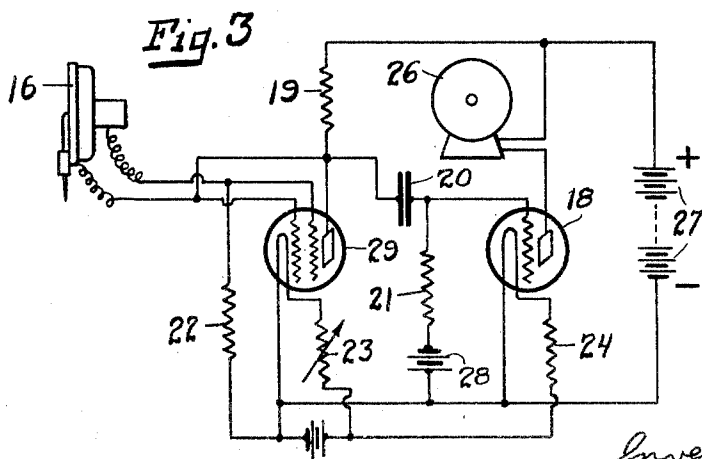
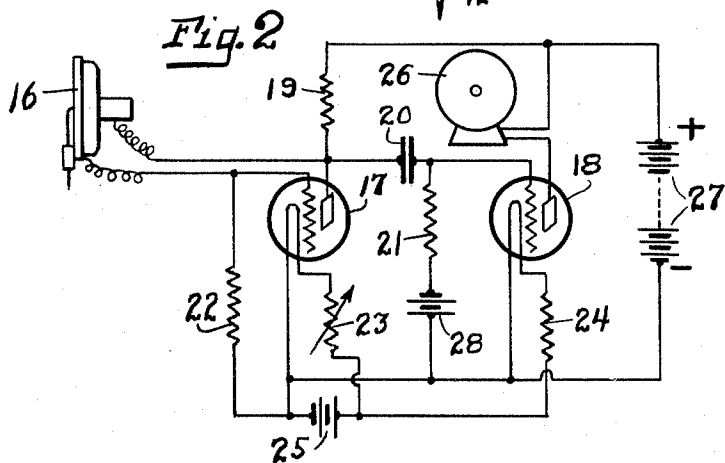
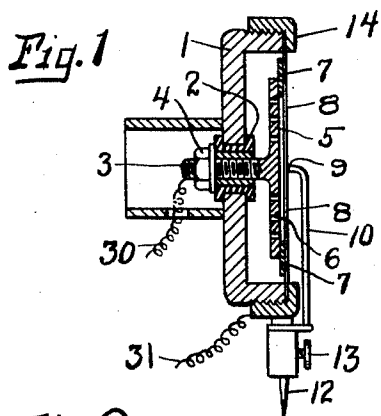
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ELECTROSTATIC PHONOGRAPH PICK-UP

Filed April 6, 1928

2 Sheets-Sheet 1



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Fig. 4

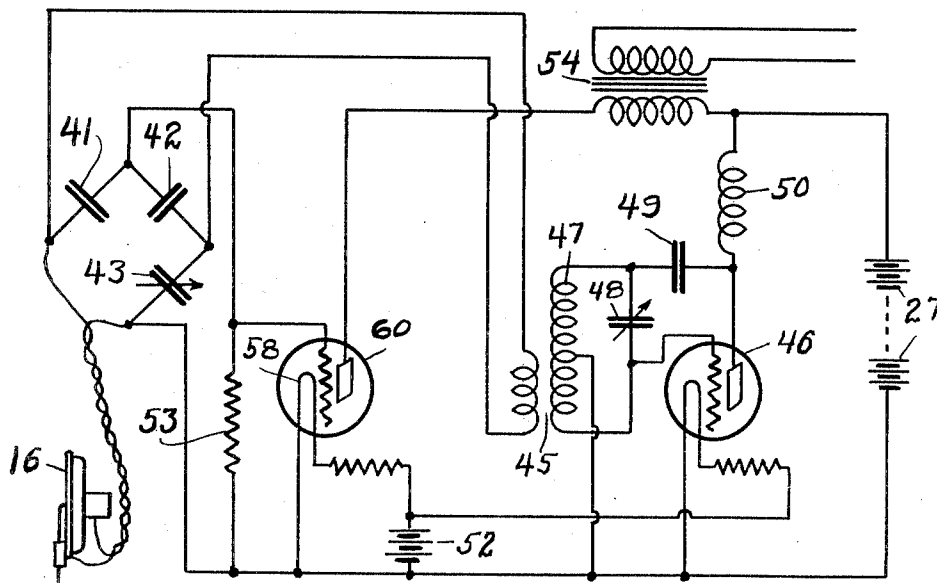
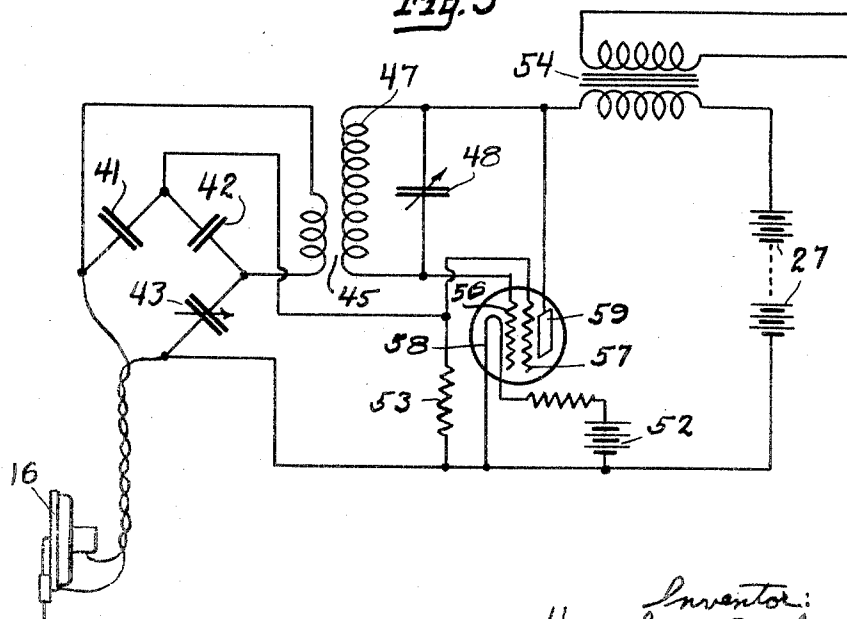


Fig. 5



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UNITED STATES PATENT OFFICE

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ELECTROSTATIC PHONOGRAPH PICK-UP

Application filed April 6, 1928, Serial No. 268,006, and in Great Britain July 22, 1927.

In the application of electrical, or thermionic amplifying devices to the reproduction of sounds from a gramophone record or the like, by electrical means in lieu of the more usual direct mechanical sound reproduction, some form of "pick-up" device is necessary for the preliminary translation of the sound record into electrical currents. The object of my invention is to provide an improved form of such pick-up device, which has material advantages over such devices heretofore known. In carrying my invention into effect I construct an electrostatic pick-up device whereby the movements of the stylus produced by the gramophone sound record are adapted to cause variations of the capacity of an electrical condenser. These capacity variations are then caused to influence an electrical circuit whereby the potential of the grid or grids of a thermionic amplifying valve are caused to vary strictly in accordance with the details of the original sound record.

In the accompanying drawings Fig. 1 is a sectional elevation of a pick-up device constructed in accordance with my invention;

Fig. 2 is a circuit diagram embodying one method of employing the said pick-up device of Fig. 1 in conjunction with a three-electrode thermionic amplifying valve;

Fig. 3 is a further circuit diagram embodying the same arrangement of pick-up in Fig. 1 used in conjunction with a four-electrode thermionic valve amplifier.

Fig. 4 is a circuit diagram embodying a method of amplification in which two three-electrode thermionic valves are employed in conjunction with a radio frequency "Wheatstone bridge" connection to the pick-up device; and

Fig. 5 is a circuit diagram differing from Fig. 4 by having one four-electrode valve substituted for the two three-electrode valves.

Referring to the drawings, reference numeral 1 designates the casing of the pick-up device which is preferably constructed in the form of a metal casting, but may if preferred be of moulded insulating material. Through the centre of this casing a bushing 2 of insulating material is fitted to carry the screw threaded rod 3 on which is the securing

nut 4 for the purpose of fixing the position of the rod 3 with respect to the casing 1.

The inner end of the rod 3 carries the circular disc 5 which is provided with a number of perforations 6. Resting on the periphery of the disc 5 is a ring 7 of insulating material, such for example as an annular washer of mica, the purpose of which is to provide insulation between the disc 5 and the flexible diaphragm 8. By adjustment of the position of the rod 3 and of the disc 5 attached thereto with respect to the casing, a greater or lesser degree of pressure can be applied between the said disc 5 and the flexible diaphragm 8, this pressure being transmitted through the insulating washer 7. The diaphragm 8 may be of thin metal or be in the form of a diaphragm of mica or similar material provided with a conducting coating. At the point 9 at or near the centre of the diaphragm 8 the lever 10 is rigidly attached, this lever being pivoted to the casing 1 by any well-known means such as is normally employed in the sound reproducer commonly used in gramophones. The stylus 12 secured in a suitable holder 13 to the lower end of the lever 10 is adapted to rest on the surface of the gramophone sound record and to be actuated thereby in the well-known manner. Electrical connections to this pick-up device are arranged one to the rod 3 and the other to the casing 1. If this casing is of conducting material the rod 3 is insulated therefrom by means of the bushing 2, or alternatively if the casing 1 is of insulating material the bushing 2 may be metallic in nature to provide a suitable bearing for the rod 3.

By adjusting the position of the rod 3 with respect to the casing 1 a greater or lesser degree of pressure can be applied to the diaphragm 8 thus tensioning the diaphragm 8 and thereby controlling its natural period of vibration. The faithfulness of reproduction of the sound from the record is considerably influenced by the natural period of the diaphragm, and it is desirable that this should be given as high a value as possible with respect to the normal frequencies which it is intended to reproduce. The casing of this device 1 is provided with a tubular ex-

tension 15 by means of which it is adapted for attachment to the "tone-arm" of an ordinary type of gramophone or similar apparatus.

In the use of this device the stylus 12 rests in the indented groove of the gramophone sound record and by the fluctuations in this groove is caused to produce movements in the centre of the diaphragm 8 and thereby vary the electrostatic capacity between this diaphragm and the fixed rigid conducting plate 5. The perforations 6 in this plate provide a means whereby the air which is trapped in the space between the plate 5 and the diaphragm 8 can move in and out of this space and prevent undue damping of the movements of the diaphragm.

The variations of electrostatic capacity of a pick-up device constructed in accordance with Fig. 1 may be caused to vary the potential of the grid electrode of a thermionic amplifying valve 17, Fig. 2, by connecting the said device, which is indicated as 16 in this diagram between the anode and the grid electrodes of the said thermionic valve. The two electrodes of the pick-up device become charged from the high tension source 27 which is applied to this amplifying valve, the positive connection being made through the resistance or impedance 19 which is connected in the anode circuit of this valve, the negative connection being made through the resistance or impedance 22 which is connected between the grid and the negative terminal of the H. T. source 27. The fluctuations of the capacity of the pick-up device 16 cause fluctuating currents to flow into and out of this device and so modify the potential of the grid of the valve 17. Corresponding changes in the anode potential of this valve are thereby produced and these may be further amplified by means of a second valve 18, in a well-known manner, such as for example by making use of the coupling condenser 20 with grid leak resistance 21 and grid bias battery 28 whereby the potential variations of the anode of the valve 17 may be passed on to the grid of the valve 18 thereby giving rise to further amplified fluctuations of the current in the anode circuit of the said valve 18. These amplified currents may be passed through the windings of a loud speaker 26 whereby they may be reproduced as sounds corresponding to the details of the record to which the pick-up device is applied. The filaments of the thermionic amplifying valves 17 and 18 may be heated by means of current derived from the battery 25 with appropriate fixed or variable series resistance 23 and 24 in accordance with well-known methods.

A somewhat increased amplification of the potential variations occasioned by the action of the pick-up device 16 may be obtained by the use of a four-electrode amplifying valve 29 in the manner indicated by the diagram Fig. 3. By applying the pick-up between the

two grid electrodes of this valve 29 a greater fluctuation of the potential of this valve may be obtained, which fluctuations may be further amplified by the second valve 18 in an exactly analogous manner to that described above in connection with Fig. 2. Alternatively the said pick-up device may be connected between the outer grid electrode and the positive pole of the H. T. source 27, whereby the polarizing voltage subjected to the said pick-up device is not reduced by the voltage drop in the impedance 19. The grid leak resistance or impedance 22 is preferably connected between the outer grid electrode of the valve 29 and the filament negative terminal of the same amplifying valve. The inner grid electrode of this valve is preferably connected to the anode of the same valve, so that the positive potential applied to that inner grid electrode serves to accelerate the electron stream from the cathode of this valve and thereby render the outer grid electrode more sensitive to potential variations occasioned by the action of the pick-up device 16 since this grid is then situated in a very weak electrostatic field between the inner grid electrode and the anode of this valve. The addition of the impedance 22 between the grid and the filament negative terminals of the valve 17 and 29 in Figs. 2 and 3 serves the purpose of locating the potential of these electrodes with respect to the cathode of the valve. In order to prevent this resistance dissipating too great a proportion of the potential fluctuations occasioned by the action of the pick-up device 16 this resistance 22 may preferably be replaced by an inductive resistance or choke coil with or without an iron core, so that the static potential of this grid electrode can be held while the electrode is still free to be actuated by rapidly varying potentials produced by the pick-up device.

Any alternative means of further amplifying the potential variations occurring in the first amplifying stage 17 or 29 may be employed without departing from the general spirit of the invention, and where required a further number of amplifying stages than that shown in the diagram may be employed when required.

In carrying my invention into effect I utilize a radio frequency "Wheatstone bridge" as shown in Fig. 4, which consists of the ratio arms 41 and 42, the adjustable arm 43, and the electrostatic pick-up device 16. The "bridge" is fed from a valve oscillator by means of the radio frequency transformer 45. The oscillating valve 46 is connected to the secondary 47 of the transformer 45 using the well-known "Hartley" circuit tuned by the variable condenser 48 and the anode connection is made through the fixed condenser 49 with the usual radio frequency choke coil 50 and high tension battery 27. The low tension battery 52 supplies the filament current

for the oscillating valve 46 and the detector valve 60, the grid and filament of which are connected across the "galvanometer arm" of the "Wheatstone bridge". The resistance 53 maintains the grid of the detector valve 60 at a sensibly zero potential with regard to the filament when the bridge is balanced. The anode of the detector valve 60 is connected through an output transformer 54 to the high tension battery 27 in well-known manner.

The action of the circuit is as follows:—

When the capacity of the electrostatic pick-up is caused to vary by sound waves or the like, the balance of the "Wheatstone bridge" is upset thereby causing a radio frequency difference of potential to occur across the grid and filament of the detector valve 60 and causing a corresponding change of current in the said valve and producing an audio frequency current in the secondary of the transformer 54, exactly similar in form to that of the sound waves which produce the variations of capacity of the electrostatic "pick-up" 16. As the "Wheatstone bridge" is fed from a radio frequency source the distortion introduced in translating the sound waves into audio frequency currents is materially reduced.

In the preferred construction of the "Wheatstone bridge", the ratio arms 41 and 42 consist of condensers as shown in Fig. 4, but it is pointed out that these may be replaced by any other form of reactance without departing from the spirit of the invention. The said ratio arms 41 and 42 may also be of unequal value in order to increase the sensitivity of the device, as the variations of the capacity of the electrostatic "pick-up" device will necessarily be small.

Another form of the same circuit is shown in Fig. 5 in which a four-electrode valve 55 is used to replace the two three-electrode valves as shown in Fig. 4. The well-known "oscillator" circuit is employed in which the inner grid 56 of the four-electrode valve 55 is maintained at a positive potential with respect to the outer grid 57. The radio frequency "Wheatstone bridge" 41, 42, 43, and 16 is fed in similar manner by means of the radio frequency transformer 45 in which the secondary 47 is tuned by the variable condenser 48 in similar manner to that of Fig. 4. The outer grid 57 and filament 58 are then connected across the "galvanometer arm", the resistor 53 being used to maintain the normal potential of the outer grid 57 as previously described. An audio frequency transformer 54 is connected between the anode 59 and the positive side of the high potential battery 27 as before.

The action of this form of the circuit is exactly similar to that of Fig. 4, wherein the variations of capacity of the electrostatic "pick-up" device produce audio frequency currents in the secondary of the transformer 54. The ratio arms 41 and 42 of the "Wheat-

stone bridge" may likewise be replaced by other forms of reactances and may be of unequal value.

It will be understood that the invention described may be applied to any other form of condenser microphone than that as referred to in the drawings, whereby the radio frequency output currents from the secondary of the transformer 54 may be used to influence in any well-known manner the modulating valve of a radio transmitter or may be further amplified and applied to a loud speaker or similar device for direct speech amplification.

Having described my invention, what I believe to be new and desire to secure and protect by Letters Patent of the United States is:—

1. Means for transforming mechanical oscillations of a phonograph stylus into corresponding electrical oscillations comprising in combination a Wheatstone bridge circuit, an electrostatic device subjected to said mechanical oscillations to change its capacity correspondingly, said device forming one arm of said Wheatstone bridge circuit, the adjacent arm of said bridge comprising a balancing condenser, two ratio arms consisting of electrical impedances for completing said bridge, whereby the fluctuations of capacity of said device vary the balance condition of said bridge in accordance with said mechanical oscillations, means to impress currents to be modulated to one of the diagonal branches of said bridge and an output utilization circuit connected to the remaining diagonal branch of said bridge carrying electrical currents varying in accordance with said balance variations.

2. Means for transforming mechanical oscillations of a phonograph stylus into corresponding electrical oscillations comprising in combination a Wheatstone bridge circuit, an electrostatic device subjected to said mechanical oscillations to change its capacity correspondingly, said device forming one arm of said bridge comprising a balancing impedance, two ratio arms consisting of electrical impedances for completing said bridge, whereby the fluctuations of capacity of said device vary the balance condition of said bridge in accordance with said mechanical oscillations, means to impress currents to be modulated to one of the diagonal branches of said bridge, a space charge controlled device having main electrodes and control electrodes, means to subject said control electrode to potential variations occurring at the end of the remaining diagonal branch of said bridge and an output utilization circuit connected to said main electrodes of said space charge device carrying electrical currents varying in accordance with said balance variations.

3. In combination, a Wheatstone bridge, an electrostatic pick up device for phono-

graphs and the like, the capacity of which varies in accordance with the mechanical oscillations of the phonograph needle, said device forming one arm of said Wheatstone bridge, the adjacent arm of said bridge comprising a balancing impedance, two ratio arms consisting of impedances completing said bridge for maintaining said bridge normally balanced, said device unbalancing said bridge in accordance with the oscillations of said needle and a source of high frequency connected to said bridge whereby said high frequency is modulated in accordance with the unbalancing of said bridge.

4. Means for transforming mechanical oscillations into corresponding electrical oscillations comprising a Wheatstone bridge circuit, an electrostatic device subjected to said mechanical oscillations to change its capacity correspondingly, said device forming one arm of said Wheatstone bridge circuit, the adjacent arm of said bridge comprising an impedance of adjustable value adapted for balancing the bridge, two ratio arms also consisting of electrical impedance for completing said bridge, whereby the fluctuations of capacity of said device vary the balance condition of said bridge in accordance with said mechanical oscillations, means to produce an alternating carrier current to be impressed on one of the diagonal branches of said bridge for being modulated in accordance with said balance variations and an output circuit including rectifying means connected to the remaining diagonal branch of said bridge for utilizing electrical currents varying in accordance with the said balance variations.

5. In an electrostatic pick-up arrangement for phonographs and the like, comprising a Wheatstone bridge circuit, an electrostatic pick-up device adapted to be subjected to mechanical oscillations to change its capacity correspondingly, said device forming one arm of said Wheatstone bridge circuit, the adjacent arm of said bridge comprising a balancing condenser, two ratio arms consisting of electrical impedances completing said bridge, whereby the fluctuations of capacity of said pick-up device vary the balance condition of said bridge in accordance with said mechanical oscillations, means to impress currents to be modulated to one of the diagonal branches of said bridge and an output circuit connected to the remaining diagonal branch of said bridge for utilizing said modulated currents.

6. In an electrostatic pick-up arrangement for phonographs and the like, comprising a Wheatstone bridge circuit, an electrostatic pick-up device adapted to be subjected to mechanical oscillations to change its capacity correspondingly, said device forming one arm of said Wheatstone bridge circuit, the adjacent arm of said bridge comprising a bal-

ancing condenser, two ratio arms consisting of electrical impedances completing said bridge, whereby the fluctuations of capacity of said pick-up device vary the balance condition of said bridge in accordance with said mechanical oscillations, means to impress a potential difference across two diagonal points of said bridge, a space charge control device having main and control electrodes, said control electrode being subjected to potential variations occurring at the ends of the remaining diagonal branch of said bridge due to said balance variations, and an output utilization circuit connected to said main electrodes of said space charge device for utilizing electrical currents varying in accordance with said balance variations.

7. In combination, a Wheatstone bridge circuit, an electrostatic pick-up device for phonographs and the like, comprising a condenser pick-up device adapted to be subjected to mechanical oscillations of a phonograph needle to change its capacity correspondingly, said device forming one arm of said Wheatstone bridge circuit, the adjacent arm of said bridge comprising a balancing condenser, two ratio arms also consisting of condensers for completing said bridge circuit, whereby the fluctuations of capacity of said device vary the balance condition of said bridge in accordance with said mechanical oscillations, means to produce superaudio frequency carrier current to be impressed on one of the diagonal branches of said bridge for being modulated in accordance with said balance variations, and an output circuit including rectifying means connected to the remaining diagonal branch of said bridge for utilizing said modulated currents.

8. Means for transforming mechanical oscillations into corresponding electrical oscillations in combination, a Wheatstone bridge circuit, an electrostatic device subjected to said mechanical oscillations to change its capacity correspondingly, said device forming one arm of said Wheatstone bridge circuit, the adjacent arm of said bridge comprising a balancing condenser, two ratio arms consisting of electrical impedances completing said bridge, whereby the fluctuations of capacity of said device vary the balance condition of said bridge in accordance with said mechanical oscillations, a space charge device having main electrodes and a plurality of control electrodes, a circuit arrangement associated with the main electrodes and one of the control electrodes of said space charge device to produce undamped continuous oscillations, circuit connections to impress said oscillations on one of the diagonal branches of said bridge, further means to impress potential variations occurring at the ends of the remaining diagonal branch of said bridge due to said balance variations on the remaining control electrode of said space charge de-

vice, a utilization output circuit of said space charge device and means to cause electric currents varying in accordance with said balance variations to flow in said output circuit.

9. In combination, a Wheatstone bridge, an electric pick up device for phonographs and the like responsive to the mechanical oscillations of the phonograph needle, said device forming one arm of said Wheatstone bridge, the adjacent arm of said bridge comprising a balancing impedance, two ratio arms consisting of impedances completing said bridge for maintaining said bridge normally balanced, said device unbalancing said bridge in accordance with the oscillations of said needle, a source of carrier current and means for modulating said carrier in accordance with the unbalance of said Wheatstone bridge circuit.

10. In combination, a Wheatstone bridge, an electric pick up device for phonographs and the like responsive to the mechanical oscillations of the phonograph needle, said device forming one arm of said Wheatstone bridge, the adjacent arm of said bridge comprising a balancing impedance, two ratio arms consisting of impedances completing said bridge for maintaining said bridge normally balanced, said device unbalancing said bridge in accordance with the oscillations of said needle, means for impressing a carrier current across one diagonal branch of circuit whereby potential variations occur at the ends of the remaining diagonal branch of said bridge due to said balance variations.

11. In combination, a Wheatstone bridge, an electric pick up device for phonographs and the like responsive to the mechanical oscillations of the phonograph needle, said device forming one arm of said Wheatstone bridge, the adjacent arm of said bridge comprising a balancing impedance, two ratio arms consisting of impedances completing said bridge for maintaining said bridge normally balanced, said device unbalancing said bridge, in accordance with the oscillations of said needle, a space charge device having main electrodes and a plurality of control electrodes, a circuit arrangement associated with the main electrodes and one of the control electrodes of said space charge device to produce undamped continuous oscillations, circuit connections to impress said oscillations on one of the diagonal branches of said bridge, further means to impress potential variations occurring at the ends of the remaining diagonal branch of said bridge due to said balance variations on the remaining control electrode of said space charge device, a utilization output circuit of said space charge device and means to cause electric currents varying in accordance with said balance variations to flow in said output circuit.

12. In combination, a Wheatstone bridge,

an electrostatic pick up device for phonographs and the like, comprising in combination an electrostatic device adapted to be subjected to mechanical oscillations of a phonograph needle to change its capacity correspondingly, said device forming one arm of said Wheatstone bridge circuit arrangement, the adjacent arm of said bridge comprising a balancing condenser, two ratio arms consisting also of condensers completing said bridge, whereby fluctuations of capacity of said device vary the balance condition of said bridge in accordance with the oscillations of said phonograph needle, a space charge device having main electrodes and at least two control electrodes, a circuit arrangement associated with said space charge device and one of the control electrodes to produce continuous oscillations, circuit connections to impress said oscillations upon one of the diagonal branches of said bridge circuit, a further means to apply potential variations occurring at the ends of the remaining diagonal branch of said bridge due to said balance variations, upon the remaining control electrode of said space charge device, and means to utilize electrical current variations corresponding to said balance variations occurring in an output circuit of said space charge device.

13. In combination, an electrostatic pick up device for phonographs, comprising in combination an electrostatic device adapted to be subjected to mechanical oscillations of a phonograph needle to change its capacity correspondingly, a space charge device having main electrodes and a plurality of control electrodes, circuit arrangements associated with said main electrodes and one of said control electrodes for producing undamped continuous oscillations, means for modulating said oscillations in accordance with the oscillations of said electrostatic device, and means to impress said modulated waves across another of said control electrodes of said space charge device, a utilization output circuit of said space charge device and means to cause electric currents varying in accordance with said modulations to flow in said output circuit.

14. In combination with an electric pick up system for phonographs comprising an electrostatic device adapted to mechanical oscillations of the phonograph needle to change its capacity correspondingly, means for generating a high frequency current, a balanced bridge, means for applying said high frequency across said bridge, means including said electrostatic device for modulating the high frequency current applied across said bridge in accordance with the amplitude of oscillation of said electrostatic device, means for amplifying said modulated oscillations, means for demodulating said modulated oscillations and a loud speaking device in op-

erative relation with said last means for operation in accordance with said demodulated oscillations.

15 15. In combination with an electric pick up system for phonographs, the method of signalling which comprises vibrating a pick up device in accordance with the record made on the phonograph, varying a capacity in accordance with the amplitude vibrations of the pick up device, applying a carrier current across a balanced Wheatstone bridge, modulating the carrier current in accordance with the varying capacity amplifying the modulated carrier current, demodulating the carrier current and operating a loud speaker device in accordance with the demodulated carrier currents.

 In testimony whereof he has affixed his signature.

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HUMFREY ANDREWES.

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