Oct. 10, 1939. G. L. USSELMAN ET AL 2,175,710

VARIABLE COUPLING ARRANGEMENT

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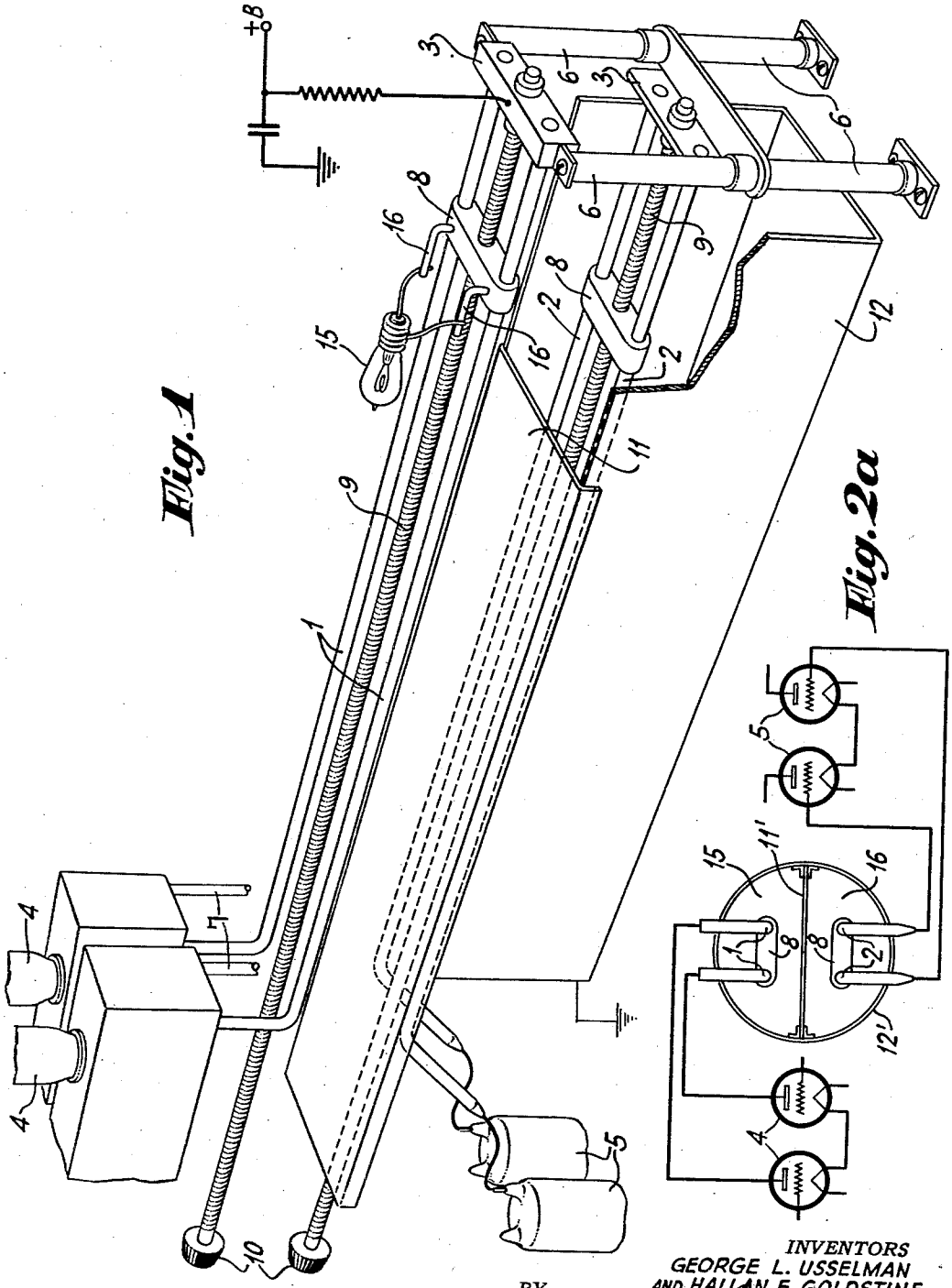


Fig. 1

Fig. 2a

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Fig. 2

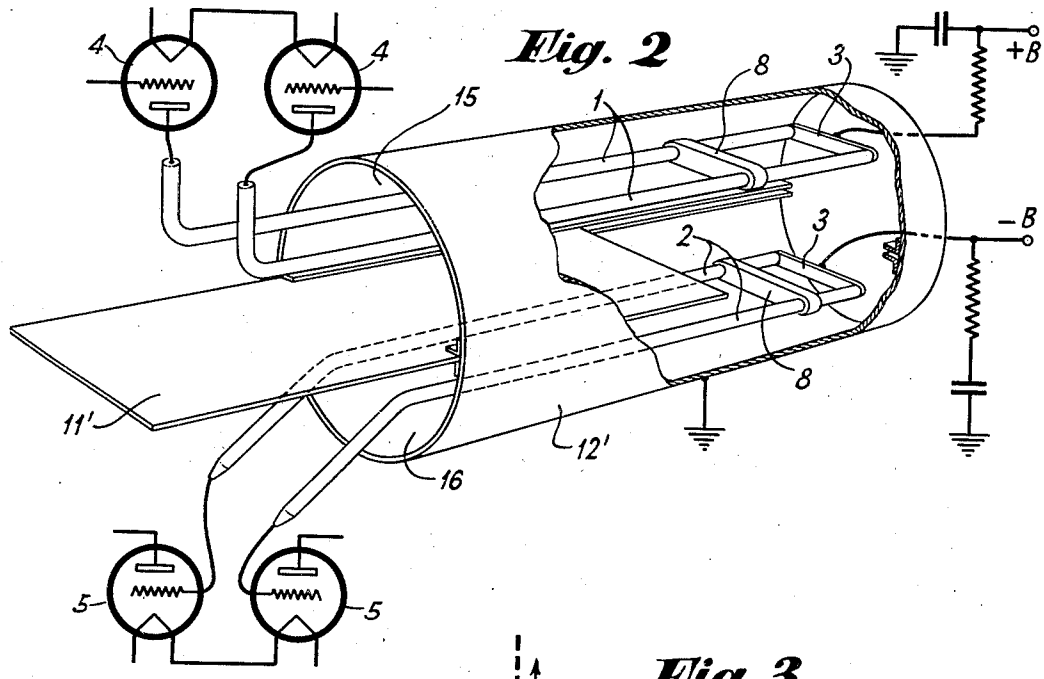
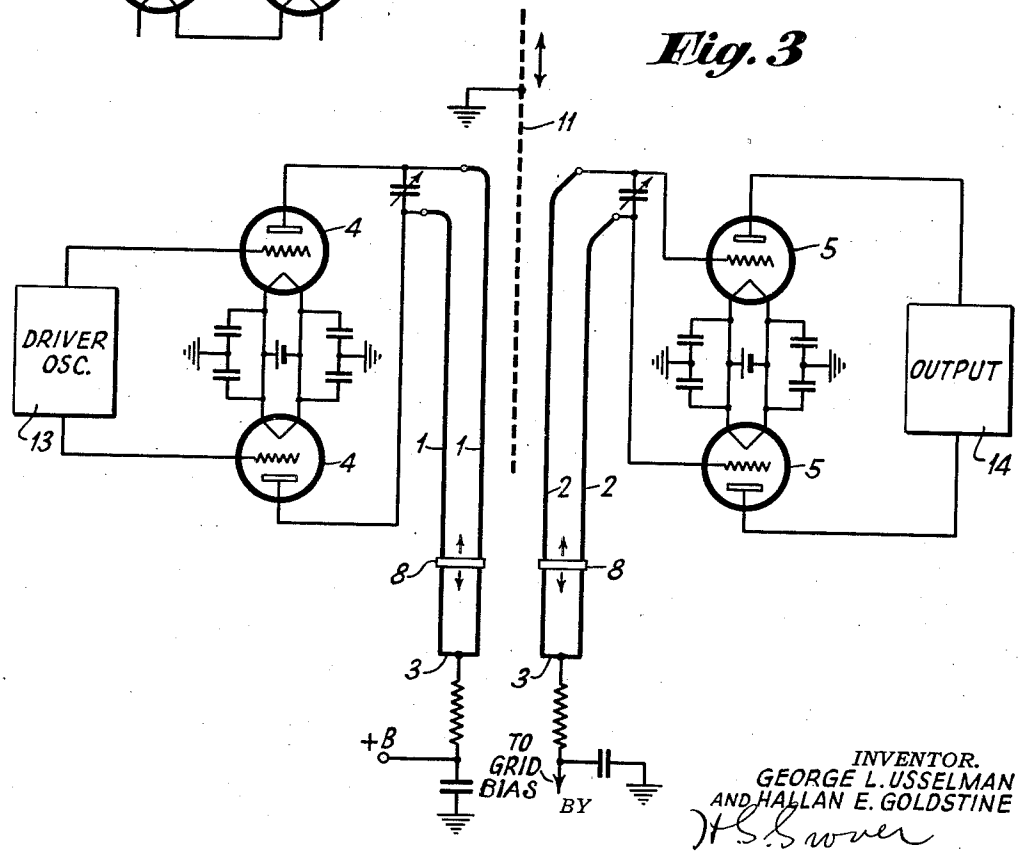


Fig. 3



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VARIABLE COUPLING ARRANGEMENT

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11 Claims. (Cl. 178—44)

This invention relates to a method of and means for varying the coupling between two parallel wire transmission line systems, such as lecher wire systems, to be used in high frequency transmitter or receiver apparatus.

In brief, the present invention provides a sliding or adjustable shield grounded for radio frequency currents, which shield is arranged to be located between two independently tunable parallel lecher wire systems for varying the coupling between the two lecher wire systems. It is proposed in the present invention to control the coupling between the two lecher wire systems near the short circuited end of each of these systems where the current is large and the voltage small, thereby providing an almost entirely magnetic coupling between the two systems. Such an arrangement has the advantage of reducing the electrostatic coupling to an extremely small amount, thus preserving a better circuit balance between the two parallel wire systems and minimizing the transfer of unwanted energy.

An important advantage of the present invention lies in the fact that two parallel wire transmission line systems which are coupled to each other may be fixedly positioned relative to each other while still permitting the coupling between the two line systems to be varied to any desired degree. Such an arrangement enables each line system to be individually tuned, that is, independently of the other line system, without upsetting the rigid and stationary construction of the parallel transmission lines.

A detailed description of the invention follows, accompanied by drawings wherein:

Fig. 1 illustrates, schematically, the essential electrical and mechanical features of applicants' invention;

Fig. 2 illustrates a modification of the arrangement of Fig. 1;

Fig. 2*a* is a plan view of the shielding cylinder of Fig. 2, and also shows, schematically, the vacuum tubes connected to the parallel conductor systems; and

Fig. 3 illustrates, by way of example only, a diagrammatic circuit showing how the arrangement of Figs. 1 and 2 may be employed between two stages of a high frequency apparatus.

In the drawings, equivalent circuit elements are designated by the same reference numerals.

Referring to Fig. 1, there are shown two lecher wire systems 1, 1 and 2, 2, each of which consists of a pair of parallel electrically conducting tubes in the same plane, said conducting tubes of each lecher wire system being short circuited at one of their adjacent ends by a metal strip 3 and connected at their other adjacent ends to the electrodes of one or more electron discharge devices, as shown. In the illustration here given, by way of example only, the lecher wire system 1, 1 is shown connected to the anodes of a pair of vacuum tubes 4, 4, while the lower lecher wire system 2, 2 is shown connected to the grids of another pair of vacuum tubes 5, 5 of the following stage. Both of these lecher wire systems are arranged in parallel planes and spaced close to one another to provide a desired degree of coupling between them. Insulating rods 6, 6 and 7, 7 serve to support the lecher wire systems 1, 1 and 2, 2 in rigid, fixed relation to one another. Individual to each of these lecher wire systems, there is provided a tuning slider 8 comprising a metallic short circuiting bar which bridges the conductors thereof. This short circuiting bar 8 is adjustable over the lengths of the rods 1, 1 or 2, 2, to vary the effective inductance thereof, by means of a threaded spindle 9 which is responsive to movement of a remotely located dial or knob 10, for varying the position of the short circuiting bar 8, thus determining the tuning of the individual parallel wire system with which it is associated. Short circuiting bars 8, 8 should be approximately opposite each other for best coupling results between the tuned circuits.

For varying the coupling between the upper parallel wire system 1, 1 and the lower parallel wire system 2, 2, there is provided a shield in the form of a movable metal plate 11 which rests on a grounded metallic shielding box 12, the upper part of box 12 being open to enable the two lecher wire systems to be inductively coupled together through the opening in the box. By moving the metal shield plate 11 over the length of the shielding box 12, the opening of the box 12 will be correspondingly changed, thus changing the degree of inductive coupling between the lecher wire systems 1, 1 and 2, 2.

Suitable polarizing potentials are applied to the anode and grid electrodes of the vacuum tubes 4, 4 and 5, 5, to which the lecher wire systems 1, 1 and 2, 2 are respectively connected by means of connections to the centers of the metal straps 3, 3 as shown.

It should be noted that the parallel wire systems 1, 1 and 2, 2 are electromagnetically coupled at a location where the current is highest in the two systems, and shielded from each other at a location where the high potentials make electrostatic coupling most troublesome.

Fig. 2 illustrates a modification of the circuit of Fig. 1, differing therefrom mainly in the use of a shielded container 12' which surrounds both of the lecher wire systems 1, 1 and 2, 2, instead of surrounding only one of the lecher wire systems as in Fig. 1. Shielded container 12' is here shown as an open-ended, grounded cylinder which is divided into two chambers 15 and 16 by means of the central, slidable, metal partition wall 11'. It is preferred that shield 11' be placed midway between tuned circuits 1, 1 and 2, 2 and in a

plane parallel to the planes of these conductors. Both sides of shield 11' are designed to make good sliding contact with the grounded cylinder 12'. Preferably, the shield 11' and cylinder 12' should be made from some highly conductive material, such as copper. The two pairs of tunable wire systems are inductively coupled to each other inside of the cylinder 12'.

It should be noted that here, as in Fig. 1, the location of the coupling between the two tuned circuits is at a place of high current flow, while the location of the shielding effected by wall 11' aids in reducing electrostatic coupling to a minimum.

The arrangement of Fig. 2, like that of Fig. 1, provides variable coupling between tuned circuits 1, 1 and 2, 2, while at the same time permitting the conductors to be rigidly mounted, a condition very desirable where the conductors of the tuned circuit carry cooling fluid.

Where desired, shield 11' may be made of two parts, the one near the high potential parts of the wires being more or less fixed while the other near the place of high current flow in the wires being movable.

Although container 12 of Fig. 1 has been shown in rectangular form, and the container 12 in Fig. 2 of cylindrical form, it will be understood that any desirable shape may be employed, whether rectangular, cylindrical or polygonal.

In some cases, it may be desirable to include a variable lumped capacity in each of the tuned circuits across the conductors thereof, to aid in adjusting bars 8, 8 to a position just opposite each other on the respective tuned circuits, see Fig. 3.

Fig. 3 illustrates, diagrammatically, how the variable coupling system of the type illustrated in Figs. 1 and 2 can be applied between two stages of a transmitter circuit, although it will be appreciated that a similar arrangement may be used in the receiver or wherever there is need for a pair of coupled parallel wire or lecher wire systems. In this figure, a suitable source of oscillations, such as a driver 13, is arranged to excite the grids of the vacuum tubes 4, 4 in push-pull relation, the output or anode electrodes of which are coupled to the lecher wire system 1, 1, in turn tuned by means of the short circuiting slider 8. Lecher wire system 1, 1 is shown coupled to a parallelly arranged lecher wire system 2, 2, which is in circuit with the grids of a pair of power amplifier electron discharge devices 5, 5, to whose output anodes is coupled any suitable output or utilization circuit 14. It should be noted that the lecher wire system 2, 2 is also provided with a tuning slider 8 in the same manner as the lecher wire system 1, 1, each system being short circuited at one of its ends by means of a conducting strap 3, to whose center is connected a suitable polarizing potential. The movable metal shield 11 is here shown diagrammatically in dotted lines, this shield being adjustable in position to provide a desired degree of coupling between the lecher wire systems 1, 1 and 2, 2.

In one particular embodiment employed in practice, the lecher conductors each consisted of a hollow rod about three-quarters of an inch in diameter. Means were provided to force fluid through the interior of these rods for cooling purposes.

Where additional loading is desired on the lecher wire systems, there may be provided a suitable energy absorbing circuit such as a lamp load 15, as shown in Fig. 1, which load may be connected to the strap 8 by means of a pair of rod-like lugs 16, 16 connected to the opposite ends of the short circuiting strap 8. These lugs 16, 16 are parallel to the conductors of the lecher wire system to provide coupling therebetween, and the connections between the lamp 15 and the lugs 16 are adjustable over the lengths of these lugs to give a variable degree of loading. This particular arrangement of the load 15 on the strap 8 enables the loading on circuit 1, 1 to remain essentially constant as the strap 8 is varied in position to tune the lecher wire system.

It will be understood, of course, that the word "ground" used in the specification and appended claims signifies any point of relatively fixed or zero radio frequency potential, and is not limited to an actual earthed connection.

What is claimed is:

1. In combination, a pair of transmission lines arranged parallel and spaced from one another to provide electromagnetic coupling therebetween, a metallic shield located between and parallel to said transmission lines, said shield being movable in the direction of the lengths of said lines for providing an unobstructed space between said lines at points of relatively low potential, whereby the electromagnetic coupling between said lines may be varied, and a connection from said shield to ground.

2. In combination, a first lecher wire system and a second lecher wire system electromagnetically coupled thereto, both of said systems being located in planes parallel to each other, and a metallic shield located in a plane between and parallel to the planes of said first and second lecher wire systems, said shield being grounded and movable in a direction parallel to the lengths of said lecher wires for providing an unobstructed space between said lines at points of relatively low potential, whereby the degree of electromagnetic coupling between said systems may be varied.

3. In combination, a tuned output circuit comprising a pair of parallel conductors located in a plane, a movable short circuiting strap bridged across said conductors, a tuned input circuit comprising a similarly arranged pair of parallel conductors located in a plane parallel to the plane of the parallel conductors of said tuned output circuit and electromagnetically coupled thereto, the short circuiting straps of said tuned output and input circuits being positioned at substantially similar locations in the lengths thereof, and a grounded, electrically conductive shield in the form of a plate located in a plane between said tuned circuits, said shield being movable in a direction along the lengths of the conductors for providing an unobstructed space between said conductors of said output and input circuits at a place near the short circuiting strap of at least one of said circuits.

4. In combination, a two-conductor transmission line arranged in a plane, fixed supports for the conductors of said line, another two-conductor transmission line arranged in a parallel plane, means for fixedly supporting said last line, said lines being magnetically coupled to each other by virtue of their spacing, an input circuit coupled to one of said lines and an output circuit coupled to the other of said lines, a shield in the form of a metallic plate located in a plane between and parallel to the planes of said two transmission lines, a connection from said shield to a point of relatively fixed alternating current potential, said shield being movable in the direction of the lengths of said lines for vary-

ing the degree of coupling therebetween, said shield being effective to shield said lines from each other at a location where the electrostatic effects are most troublesome.

5. In combination, a tuned circuit in the form of a two-conductor transmission line, another tuned circuit also in the form of a two-conductor transmission line, said tuned circuits being arranged in parallel planes and coupled to each other by virtue of the spacing of said conductors, fixed supports for the conductors of said lines, means for short circuiting each of said transmission lines at correspondingly located positions for radio frequency energy, tuning means bridged across the conductors, a shielding container arranged around a portion of one of said lines, said container having an opening for enabling coupling between said lines and a metallic shielding door for varying the size of said opening, said shielding door being grounded and movable over the length of said container for varying the coupling between said lines, said shielding door being effective to shield said lines from each other at a location where the electrostatic effects are most troublesome.

6. In combination, a first lecher wire system and a second lecher wire system, both of said systems being located in planes parallel to each other, and a grounded metallic shield located in a plane between and parallel to the planes of said first and second lecher wire systems, said shield being movable in a direction parallel to the lengths of said lecher wires for varying the degree of coupling between said systems, said shield being effective to shield the systems from each other at a location where the electrostatic effects are most troublesome, and to enable electromagnetic coupling between said systems at the location where there is greatest current flow therein.

7. In combination, a tuned output circuit comprising a pair of parallel conductors located in a plane, a movable short circuiting strap bridged across said conductors, a tuned input circuit comprising a similarly arranged pair of parallel conductors located in a plane parallel to the plane of the parallel conductors of said tuned output circuit and also having a short circuiting strap, the short circuiting straps of said tuned output and input circuits being positioned at substantially similar locations in the lengths thereof, an electrically conductive shield in the form of a plate located in a plane between said tuned circuits, said shield being grounded and movable in a direction along the lengths of the conductors, and means in shunt of said output circuit for enabling the load on said output circuit to remain substantially constant with movement of its short circuiting strap.

8. In combination, a tuned output circuit comprising a pair of parallel conductors located in a plane, a movable short circuiting strap bridged across said conductors, a tuned input circuit comprising a similarly arranged pair of parallel conductors located in a plane parallel to the plane of the parallel conductors of said tuned output circuit and also having a short circuiting strap, the short circuiting straps of said tuned output and input circuits being positioned at substantially similar locations in the lengths thereof, an electrically conductive shield in the form of a plate located in a plane between said tuned circuits, said shield being grounded and movable in a direction along the lengths of the conductors, and means in shunt of said output circuit for enabling the load on said output circuit to remain substantially constant with movement of its short circuiting strap, said means including a pair of conductors connected substantially to opposite ends of said last short circuiting strap and extending adjacent and parallel to the conductors of said output circuit for inductive coupling thereto, said means also including a load connected across said last pair of conductors, the connections of said load to said last pair of conductors being movable over the lengths of said last conductors.

9. In combination, a tuned circuit in the form of a two-conductor transmission line, another tuned circuit also in the form of a two-conductor transmission line, said tuned circuits being arranged in parallel planes and coupled to each other by virtue of the spacing of said conductors, fixed supports for the conductors of said lines, means for short circuiting each of said transmission lines at correspondingly located positions for radio frequency energy, tuning means bridged across the conductors, a shielding container arranged around a portion of both of said lines, said container having an opening for enabling coupling between said lines, and a metallic shielding door for varying the size of said opening, said shielding door being grounded and movable over the length of said container for varying the coupling between said lines, said shielding door being effective to shield said lines from each other at a location where the electrostatic effects are most troublesome.

10. In combination, a tuned circuit in the form of a two-conductor transmission line, another tuned circuit also in the form of a two-conductor transmission line, said tuned circuits being arranged in parallel planes and coupled to each other by virtue of the spacing of said conductors, fixed supports for the conductors of said lines, means for short circuiting each of said transmission lines at correspondingly located positions for radio frequency energy, tuning means bridged across the conductors, a shielding container arranged around a portion of only one of said lines, said container having an opening for enabling coupling between said lines and a metallic shielding door for varying the size of said opening, said shielding door being grounded and movable over the length of said container for varying the coupling between said lines, said shielding door being effective to shield said lines from each other at a location where the electrostatic effects are most troublesome.

11. In combination, a pair of two-conductor transmission lines arranged parallel and spaced from one another to provide electromagnetic coupling therebetween, each of said pair of lines being short-circuited at one end and connected at its other end to electron discharge devices, said short circuited ends being positioned at substantially similar locations in the lengths of the lines and being separated solely by etheric space at the portions thereof near the short-circuited ends, and a grounded metallic shield located between said pair of transmission lines controlling the area of unobstructed space between said portions with a consequent control of the electromagnetic coupling between said lines, whereby electrostatic coupling between said lines at undesired frequencies is reduced.

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