April 1, 1958 R. F. RYCHLIK 2,829,367

TELEVISION LEAD-IN COUPLER

Filed Feb. 26, 1953 2 Sheets-Sheet 1

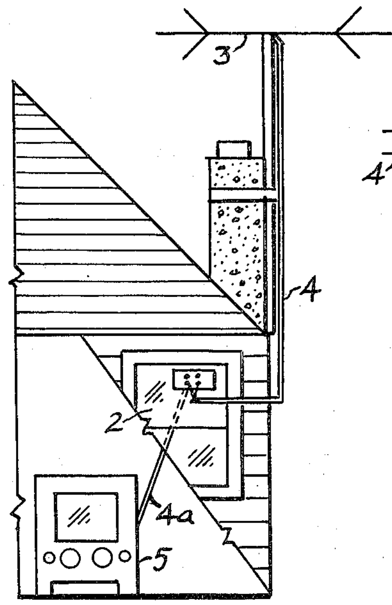

Fig. 1

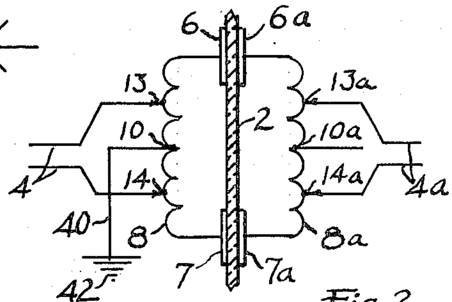

Fig. 2

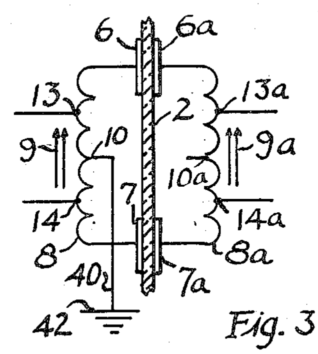

Fig. 3

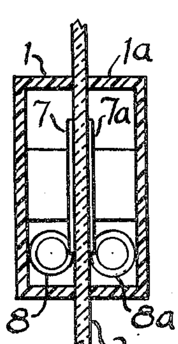

Fig. 4

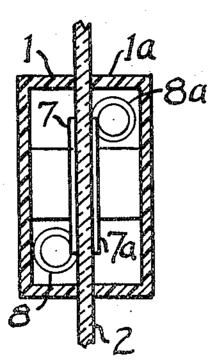

Fig. 5

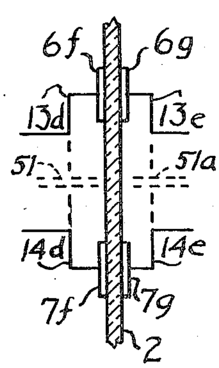

Fig. 6

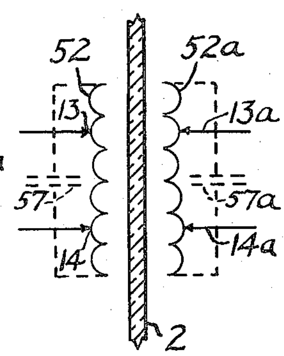

Fig. 7

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Fig. 8

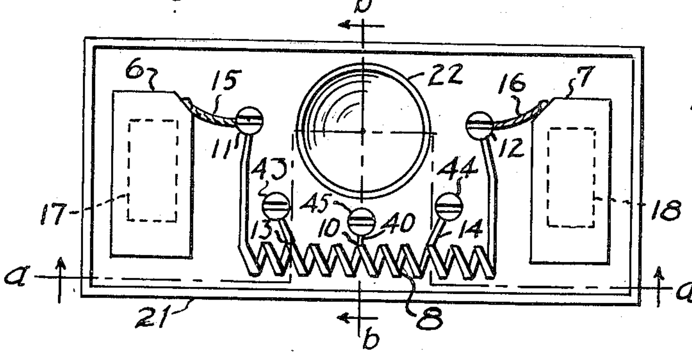
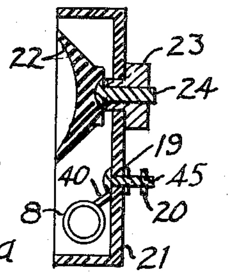


Fig. 9



Section b-b

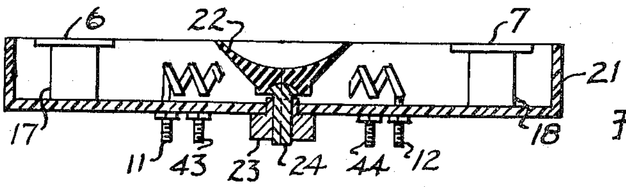
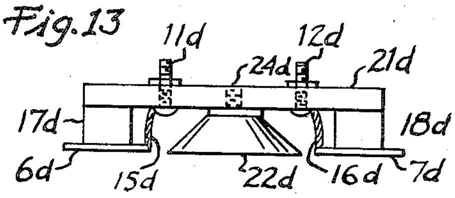


Fig. 10

Section a-a

Fig. 13



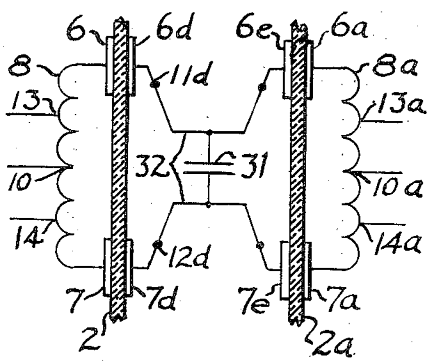


Fig. 14

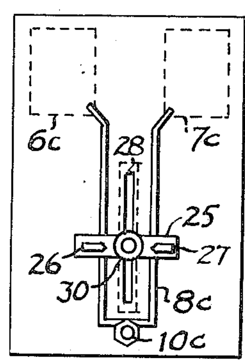


Fig. 11

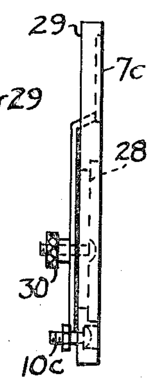


Fig. 12

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TELEVISION LEAD-IN COUPLER

Robert F. Rychlik, Dayton, Ohio

Application February 26, 1953, Serial No. 339,038

11 Claims. (Cl. 343—850)

The object of this invention is to provide a means for connecting an electrical transmission line from an antenna situated externally on a building to an electrical transmission line connected to a television set or other radio apparatus situated inside said building without a necessity for piercing the walls, sashes, frames, or window panes of that building.

Aside from this primary objective, the device provides electrical isolation at power line or direct current frequencies between the antenna and the television or radio apparatus, it also provides added lightning stroke protection, attenuation of some types of interfering signals, and means for transition from one type of transmission line to another, together with means for improvement in performance by reduction of reflections in the antenna transmission lines, which might occur if a line were brought into a building by squeezing same in a steel casement window sash.

With particular reference to the drawings,

Fig. 1 is a diagrammatic view of a television receiving installation showing the general application of this lead-in device with one unit mounted on the exterior surface of a window pane and connected to an external antenna and with the other unit of the device mounted on the interior surface of the window pane and connected to a television receiver.

Fig. 2 is a circuit diagram of the lead-in device showing the window pane as a dielectric means in the coupling capacitors of same.

Fig. 3 is another circuit diagram of a variant of this lead-in device showing the central parts of the inductors of the device as adjustable elements, which is an alternative to the tapped inductors shown in Fig. 2.

Fig. 4 is a vertical sectional view of the lead-in device with its inductors in position for maximum inductive coupling.

Fig. 5 is a vertical elevation view showing one unit of the device inverted with respect to the other in a position for least inductive coupling and maximum interference attenuation.

Figs. 6 and 7 are diagrammatic views showing two different modifications of this lead-in device where only capacitive and only inductive elements are used, respectively.

Figs. 8, 9, and 10 show the lead-in device as it is designed and manufactured for use at television very high frequencies, where a combination of inductive and capacitive coupling combined with auto-transformer action is used to obtain maximum energy transfer efficiency when the device is inserted in the antenna connecting line.

Figs. 11 and 12 show the ultra high frequency design of the device wherein the inductance elements of the units take the form of parallel lines with fixed or adjustable tap connections to permit maximum energy transfer between the antenna and the television or radio apparatus.

Figs. 13 and 14 show an accessory device used in conjunction with the lead-in device to permit energy transfer through double windows, commonly referred to as storm windows.

The subject of this patent application is a means for providing a connecting device between an electrical transmission line connected to an external antenna and another transmission line connected to a television or radio apparatus situated inside a building on which the subject antenna may be mounted. The object is to attain efficient energy transfer between the antenna and the other apparatus without necessity for maintaining the physical continuity of the transmission line by threading same through a hole in the containing structure.

The lead-in device which is the subject of this patent application comprises two similar, but not necessarily identical, halves which are intended to be placed on opposite sides of a window pane of an outside window of the building involved. These half portions, or units, together comprise the complete lead-in device or coupler, one unit being connected to the antenna transmission line, the other unit being connected to the line that conects to the radio or television apparatus.

The principles of operation invoked in this device are as follows. A capacitance can be inserted in an electrical circuit with minimum voltage loss effect if the point at which that capacitance is connected is a high impedance point in the circuit. Second, a low impedance can be converted into an effectively high impedance by transformer or auto-transformer techniques and again restored to a low impedance by a reversal of the same process. Third, in a combination of inductive and capacitive coupling, one can be augmented by the other to produce effective energy transfer over a fairly wide frequency range.

Referring to Fig. 2, the antenna line **4**, which is a low impedance termination, connects to the auto-transformer inductor coil **8** at the taps **13** and **14** indicated by the arrowheads, which may be fixed taps or adjustable, as desired in the particular design, and by auto-transformer action a high impedance transformation occurs to the ends of coil **8** where capacitor plates **6** and **7** are connected. These plates, together with plates **6***a* and **7***a*, constitute a pair of capacitors when the window pane **2** is interposed between them, since glass is an effective dielectric. The antenna energy is then present at the terminals of coil **8***a*, but at a relatively high impedance level comparable to that at the terminals of coil **8** in the same figure. Coil **8***a*, being tapped at points **13***a* and **14***a* in a fashion similar to the taps on coil **8**, is then capable of adapting the high impedance energy at plates **6***a* and **7***a* to the low impedance level of the transmission line leading, for example, to a television set **5** (Fig. 1) and connected as shown by the transmission line **4***a* to taps **13***a* and **14***a* on coil **8***a* (Fig. 2), the reverse transformation being accomplished in the interior unit of the lead-in device thereby.

As stated previously, the impedance transformation could likewise be accomplished with double winding transformers in place of the auto-transformers, but in this application the auto-transformer is illustrated because it accomplishes the same function and provides the simplest construction. Since inductors **8** and **8***a* (Fig. 2) are present in fairly close proximity, it is feasible to take advantage of this to augment the capacitive coupling in the device with inductive coupling. Thereby it is possible to maintain efficient energy transfer over a wide frequency range such as may be encountered in television applications.

In Fig. 3 is shown a constructional variant of the device discussed in Fig. 2 and it differs primarily that instead of either fixed or adjustable tap points on the inductors, a portion of the auto-transformers is constructed in such fashion that its inductance may be varied to permit suitable adjustment of the auto-transformer impedance to the transmission line to permit insertion of the device into the transmission line with minimum energy loss and to accommodate a variety of impedance types of transmission lines without necessity for choosing terminals on the unit. Since this construction is more involved and requires more skill in its application, it is not being manufactured at present, but may be manufactured at a future date, hence it is mentioned in this application.

In Fig. 4 is shown an end sectional view of the device as mounted on a window pane **2** and when same are mounted in the position shown, they are positioned for maximum inductive coupling. This is the position in which the units are generally mounted on the window pane. The individual units are shown in Fig. 8.

Since the design of Fig. 8 lends itself to the position of the units as drawn in sectional end view Fig. 5, where one unit is inverted with respect to the other unit, it becomes possible to place the coils **8** and **8*a*** in a separated position. Installation of the units in this manner provides minimum inductive coupling, which is sometimes desirable where low frequency interference signal components are present. Since low frequency components are not as efficiently transferred by the capacity elements, they are discriminated against by this type of installation where the inductors provide additional rejection by their short-circuiting effect at lower frequencies.

In Fig. 6 is shown a less desirable simplification of the lead-in device where the plates **6*f*** and **7*f*** have been increased in size to permit transfer of the energy at a low impedance level directly to the transmission lines without use of impedance step-up, otherwise than such as might occur through standing waves on the transmission lines themselves, in which case condensers **51** and **51*a*** might be used optionally to augment this condition and promote transfer of energy. This system is considered inferior to the one which is the main subject of this application since it involves physically larger components and depends for successful operation on the fact that it would operate best when introduced into the high impedance points generated in a transmission line if same is improperly terminated, the latter condition being one which it is desirable to avoid. It also lacks the other desirable features such as interference attenuation and added lightning protection of the auto-transformer construction. As the frequency to be transferred increases, however, this type construction becomes more feasible and is considered a crude alternative to the unit shown in Fig. 11.

Fig. 7 shows a sectional view of another less desirable simplification where only inductive components **52** and **52*a*** are used to transfer the energy through the window pane **2** by electromagnetic induction. Like the other simplification in the preceding figure (Fig. 6), this model is less efficient in that it is less adaptable to ambient conditions in the installation and cannot accommodate the variety of transmission line types and impedances that can be efficiently accommodated by the designs of Figs. 2 and 8. Its principle of operation is that of a radio frequency transformer and it lacks the adaptability of the other design even if optionally constructed with inductors **52** and **52*a*** in a variable design. Capacitors **57** and **57*a*** are optional. The alternative constructions of the device shown in Figs. 6 and 7 are mentioned in this application chiefly because in the physical construction of either capacitive or inductive elements, it is inherent that some capacity will be present in an inductor and some inductance will be present in a capacitor and the inventor wishes to obtain protection in this application against simplifications of the device which might be competitive even though less desirable. It is conceivable that the manufacture of either one might be contemplated for an economy type model, hence they are being included in this application from that standpoint. Mechanical means

for mounting the components of subject simplified designs would take a form similar to those suitable for the auto-transformer device and could be suction cups or adhesive means as desired.

Referring again to Fig. 2 and to Fig. 8, it will be noted that a center tap **10** is provided on the units, same being connected by a conductor **40** to the terminal screw **45**. This tap connection has a multiple function. First, it provides a metallic path **40** between the antenna line **4** and the earth **42**, when grounded as shown. This allows induced static charges to leak away from the antenna without sparking across an air gap that might exist in the input coils of the television receiver, thus it prevents charges from accumulating on the antenna and likewise lessens danger of lightning strokes as well as avoidance of picture deterioration in television reception if static charges were allowed to spark over in the receiver input circuit. Second, when the center tap is grounded, stray interference induced on both sides of a parallel antenna transmission line produces reverse magnetic fields in the coil **8** and since it reaches both input taps **13** and **14** with the same polarity, it does not appear at plates **6** and **7**, nor does it produce a uni-directional field in the coil **8** since the resultant magnetic fields cancel each other. Therefore, such stray line pick-up potentials, even though in the television frequency range, is cancelled out in the lead-in device. The third function of center tap **10** is to provide a means for a transition from parallel transmission line to coaxial type line. For example, the antenna line may be a coaxial type line with its outer or shield conductor connected to the center tap **10** of the outer unit and its inner conductor connected to tap **13**. The line to the receiver connected to the interior unit may then be a parallel transmission line connected to taps **13*a*** and **14*a*** on said unit.

In Figs. 8, 9 and 10 are shown three views of the lead-in device (one unit only) since the other unit is similar in design.

The various components which comprise a unit are mounted on a dielectric or insulating material plate **21** whose edges can be formed as shown in Fig. 9 sectional view to complete a shallow box which also thus serves to protect the other components from the weather. Inside the box **21** is the auto-transformer inductor **8** with its tap and terminal posts **11**, **12**, **43**, **44**, and **45**; the capacitor plates **6** and **7**, which are fastened to elastic compression blocks **17** and **18**, same being sponge or foam rubber blocks or alternatively, flat metal springs whose function is to press plates **6** and **7** against the window pane; an elastic suction cup **22**, whose function is to hold the unit on the window; and flexible metallic braid connectors **15** and **16** whose function is to provide connections between the ends of coil **8** and the capacitor plates **6** and **7** if the members **17** and **18** are non-conducting. The suction cup **22** has a screw **24** imbedded in its narrow end and a shoulder nut **23** fastens the housing **21** to the suction cup.

Variants of this construction, such as molding all the components in insulating material and fastening same to window by means of suction cups or adhesives or stamping some or all of the metallic components in printed circuit fashion are other possible design versions of the device.

Figs. 11 and 12 are two views of this device as designed for ultra-high frequency applications. In this case the components are mounted on a flat dielectric plate **29**, or they may be sheet metal stamped into a similarly shaped configuration to comprise capacitor plates **6*c*** and **7*c*** with the transmission line type inductor **8*c*** taking the place of coil **8** in Fig. 2. A sliding insulating member **25** carrying metallic contacts **26** and **27** is used to provide transmission line connections with the inductor **8*c*** at the proper impedance, or alternatively, fixed taps may be substituted for the sliding contacts at suitable points if lines of known impedance are used for transmission. Again, two such units comprise a complete lead-in device as in the preceeding case. Electrically, this design is identical to that in Figs. 2, 8, 9 and 10, except for frequency operating range, and likewise lends itself to design variants in physical mounting and fabrication. The center tap is likewise provided for use with coaxial transmission lines and grounding.

In Fig. 13 is shown the accessory used with the lead-in device for transferring the signal through two window panes as may be the case where storm windows are involved. This device is essentially that shown in the circuit of Fig. 6 and physically takes the form of the structure shown in Fig. 8, less the inductor and the weatherproofing housing. Two such units are connected as shown in Fig. 14 by means of a length of parallel transmission line which has capacitance **31** inserted at a point near its center, said capacitance forming a common coupling point for the two halves of line **32** and permitting the plates at *6d* and *7d* to appear as high impedance points in the system by virtue of the impedance step-up characteristics of line **32**, which in this case acts as an impedance transformer. These units are presently manufactured as the accessory described and as a cheaper substitute for the lead-in device described in Fig. 8 when connected as shown in Fig. 6.

The advantages of this lead-in device as described in the foregoing specifications are:

A. This device provides a means whereby a satisfactory electrical connection can be effected between an antenna mounted externally on a building and a radio or television apparatus situated within said building without necessity for retaining the physical continuity of the connecting transmission line by boring a hole through the walls, sashes, windows, or other parts of the structure.

B. That the device provides electrical isolation at direct current and power line frequencies between the antenna and radio or television apparatus, thereby providing greater inherent safety from electrical shock and fire hazard in the installation.

C. That inasmuch as this device permits the attachment of an earth connection to the antenna transmission line, by means of its center taps, it provides added lightening protection by permitting static charges which would otherwise build up on the antenna and attract lightning, to pass to ground, thus maintaining said antenna at ground D. C. potential at all times.

D. That the device provides attenuation to lower frequencies than those in its operating range since it employs an inductor which is substantially a short circuit to lower frequencies.

E. That the device attenuates stray signals in the operating frequency range if they are induced simultaneously in both sides of the antenna transmission line.

F. That the device provides a means for affecting a transition from parallel conductor transmission lines to co-axial type line, or the reverse, as desired.

G. That the device improves reception of television pictures by virtue of the fact that reflections on the line are minimized by availability of connection points of proper impedance as represented by the tapped or sliding connections and the variable center inductor portions shown in the several portions and drawings that are part of the specification.

H. That this device improves television reception by obviating undesirable electrical line reflections which arise when a line is brought into a building by squeezing same in a metal casement sash or threading through a hole in a metal frame or wall.

I. That this device provides a means for simultaneously transferring very high frequencies and ultra-high frequencies on diverse types of transmission line to corresponding lines in the interior of the building.

J. That the device, with its accessory of Figs. 13 and 14 provides a means for transfer of radio or television signal energy through double pane windows, commonly known as storm windows.

I claim:

1. A low impedance television signal coupling device including a box shaped insulating member having an open side, a flexible suction cup having a threaded shaft projecting from its base portion away from its rim, a nut rotatably mounted in said insulating member threaded upon said threaded shaft, a set of metal plates, an individual resilient mounting mounted upon the inner face of said insulating member opposite said open side for individually supporting each of said plates adjacent to said open side, a coil mounted within said insulating member, a plurality of terminals on said insulating member, said coil having a plurality of terminals electrically connected to the terminals on said insulating member and a plurality of terminals electrically connected individually to said plates, said coil extending substantially between said plates and having its axis substantially in alignment with said plates but offset from the line of the centers of the plates.

2. A low impedance television signal coupling device including a shallow box shaped insulating member having a large closed side and an open side, spaced sponge rubber blocks fastened to the inner surface of said large closed side, two individual conducting capacitor plates separately mounted upon said sponge rubber blocks substantially parallel to said closed side, said blocks being sufficiently thick to protrude from said open side and hold said plates outside the confines of said insulating member, a coil having a first end connected to the first of said plates and a second end connected to the second of said plates, said insulating member having a first terminal connected to a point on said coil intermediate the center and one end and a second terminal connected to a point on said coil intermediate the center and the other end.

3. A low impedance television signal coupling device including a shallow box shaped insulating member having a large closed side and an open side, spaced sponge rubber blocks fastened to the inner surface of said large closed side, two individual conducting capacitor plates separately mounted upon said sponge rubber blocks substantially parallel to said closed side, said blocks being sufficiently thick to protrude from said open side and hold said plates outside the confines of said insulating member, a coil having a first end connected to the first of said plates and a second end connected to the second of said plates, said insulating member having a first terminal connected to a point on said coil intermediate the center and one end and a second terminal connected to a point on said coil intermediate the center and the other end, said insulating member also having a third terminal connected to the center point on said coil.

4. A low impedance television signal coupling device including a shallow box shaped insulating member having a large closed side and an open side, spaced sponge rubber blocks fastened to the inner surface of said large closed side, two individual conducting capacitor plates separately mounted upon said sponge rubber blocks substantially parallel to said closed side, said blocks being sufficiently thick to protrude from said open side and hold said plates outside the confines of said insulating member, a coil having a first end connected to the first of said plates and a second end connected to the second of said plates, said insulating member having a first terminal connected to a point on said coil intermediate the center and one end and a second terminal connected to a point on said coil intermediate the center and the other end, said insulating member having a third terminal connected to the first end of said coil and a fourth terminal connected said second end of said coil.

5. A television installation including an antenna located outside a building and a television receiver within the building having terminals adapted to be connected to the

antenna, said building having a glass window, a set of two spaced metal plates on each side of the pane of said window directly opposite each other, separate coils on each side of the window, each having one end connected to one of said plates on the same side of the window and a second end connected to the second of said plates on the same side of the window, two substantially uniformly spaced conductors connecting said antenna to two separated points on the coil on the outside of said window, two substantially uniformly spaced conductors connecting the terminals of said television receiver with two separated points on the coil on the inside of the window, said coils having their axes substantially parallel and being sufficiently close together to form a magnetic coupling.

6. A television installation including an antenna with two terminals located outside a building and a television receiver within the building having two terminals adapted to be electrically connected to the two terminals of the antenna, said building having a glass window, a set of two spaced metal plates in flat contact on each side of the window directly opposite each other, separate wire coils on opposite sides of the window having their axes parallel and sufficiently close together to form a magnetic coupling, each coil having one end electrically connected to one of said plates on the same side of the window and a second end connected to the second of said plates on the same side of the window, the central point on the coil on the outside of the window being connected to the ground, two substantially uniformly spaced electrical conductors connecting respectively the two terminals of said antenna to points intermediate the center ground connection and each end on the coil outside the window, two substantially uniformly spaced electrical conductors connecting respectively to an intermediate point in each half of the coil on the inside of the window with the two terminals of the television receiver.

7. A television installation including an antenna with two terminals located outside a building and a television receiver within the building having two terminals adapted to be electrically connected to the two terminals of the antenna, said building having a glass window, a set of two spaced metal plates in flat contact on each side of the window directly opposite each other, separate wire coils on opposite sides of the window having their axes parallel and sufficiently close together to form a magnetic coupling, each coil having one end electrically connected to one of said plates on the same side of the window and a second end connected to the second of said plates on the same side of the window, the central point on the coil on the outside of the window being connected to the ground, two substantially uniformly spaced electrical conductors connecting respectively the two terminals of said antenna to points intermediate the center ground connection and each end on the coil outside the window, two substantially uniformly spaced electrical conductors connecting respectively to an intermediate point in each half of the coil on the inside of the window with the two terminals of the television receiver, said window being in the form of spaced panes having metal plates in the space between the panes located in flatwise contact with the panes directly opposite the metal plates connected to the antenna and the television receiver, separate electrical connections connecting each of the plates in said space on one side of the panes separately with a different plate in said space on the other pane, and a capacitor connected between said separate electrical connections.

8. A television installation including an antenna located outside a building and a television receiver within the building having terminals adapted to be connected to the antenna, said building having a glass window, a set of two spaced metal plates on each side of the pane of said window directly opposite each other, an inductor

on each side of the pane of the window, said inductors each having two spaced terminals with one of the spaced terminals connected to one of the metal plates on the same side of the pane of the window and the other of the spaced terminals connected to the other of the metal plates on the same side of the pane of the pane of the window, two substantially uniformly spaced conductors extending from said antenna to two separated points on the inductor on the outside of the window, two substantially uniformly spaced conductors extending from the terminals of the television receiver to two separated points on the inductor on the inside of the window, said inductors being located sufficiently close together in mutually inductive relation to form magnetic coupling.

9. A television installation including an antenna located outside a building and a television receiver within the building having terminals adapted to be connected to the antenna, said building having a glass window, a set of two spaced metal plates on each side of the pane of said window directly opposite each other, an inductor on each side of the pane of the window, said inductors each having two spaced terminals with one of the spaced terminals connected to one of the metal plates on the same side of the pane of the window and the other of the spaced terminals connected to the other of the metal plates on the same side of the window pane, each of said inductors having tapping arrangements providing different values of inductance for impedance matching purposes, said tapping arrangements each including two spaced terminals, two substantially uniformly spaced conductors extending from said antenna to the two spaced terminals of the tapping arrangement of the inductor on the outside of the window, two substantially uniformly spaced conductors extending from the terminals of the television receiver to the two spaced terminals of the tapping arrangement of the inductor on the inside of the window, said inductors being located sufficiently close together in mutually inductive relation to form a magnetic coupling.

10. A television installation including an antenna located outside a building and a television receiver within the building having terminals adapted to be connected to the antenna, said building having a glass window, a set of two spaced metal plates on each side of the pane of said window directly opposite each other, an inductor on each side of the pane of the window, said inductors each having two spaced terminals with one of the spaced terminals connected to one of the metal plates on the same side of the pane of the window and the other of the spaced terminals connected to the other of the metal plates on the same side of the window, each of said inductors having conductors and adjustable taps movable along the conductors providing adjustably spaced terminals to provide adjustable line matching impedance, two substantially uniformly spaced conductors extending from said antenna to the two spaced terminals of the adjustable taps of the inductor on the outside of the window, two substantially uniformly spaced conductors extending from the terminals of the television receiver to the two spaced terminals of the adjustable taps of the inductor on the inside of the window, said inductors being located sufficiently close together in mutually inductive relation to form a magnetic coupling.

11. A low impedance television signal coupling device including a box shaped insulating member having an open side, a flexible suction cup protruding from the open side and having a threaded shaft projecting from its base portion away from its rim and extending through the side of the insulating member opposite the open side, a nut rotatably mounted in said insulating member threaded upon said threaded shaft on the opposite side of said member from the cup, a set of two metal plates, an individual resilient mounting for each plate mounted upon the inner face of said insulating member opposite said open side and extending therefrom to the open side and

connecting to one of the plates for individually supporting each of said plates adjacent to said open side, a coil mounted within said insulating member, a plurality of terminals on said insulating member, said coil having a plurality of terminals electrically connected to the terminals on said insulating member and a pair of terminals electrically connected individually to said plates.

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