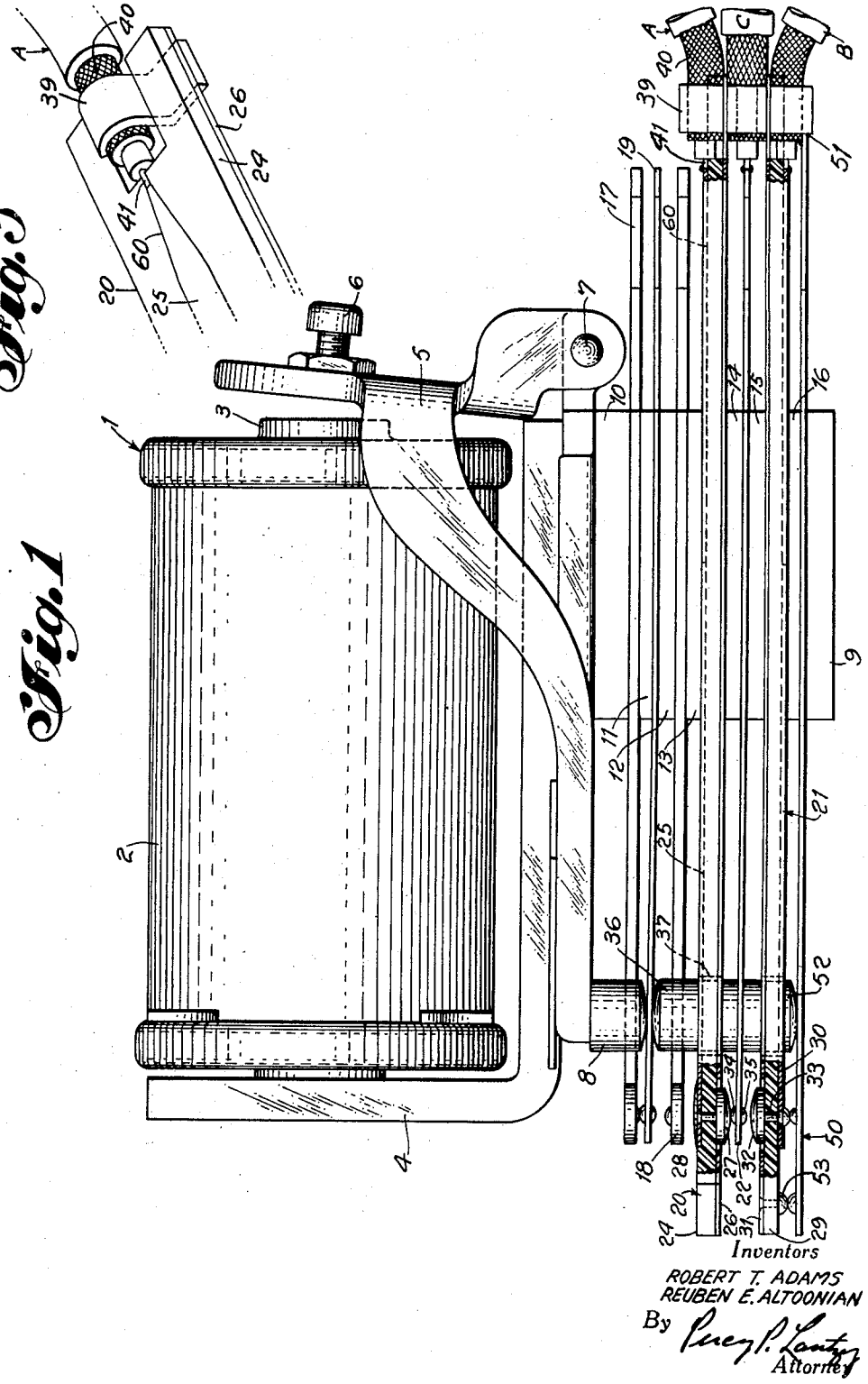
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MICROSTRIP SWITCH

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Fig. 3

Fig. 1



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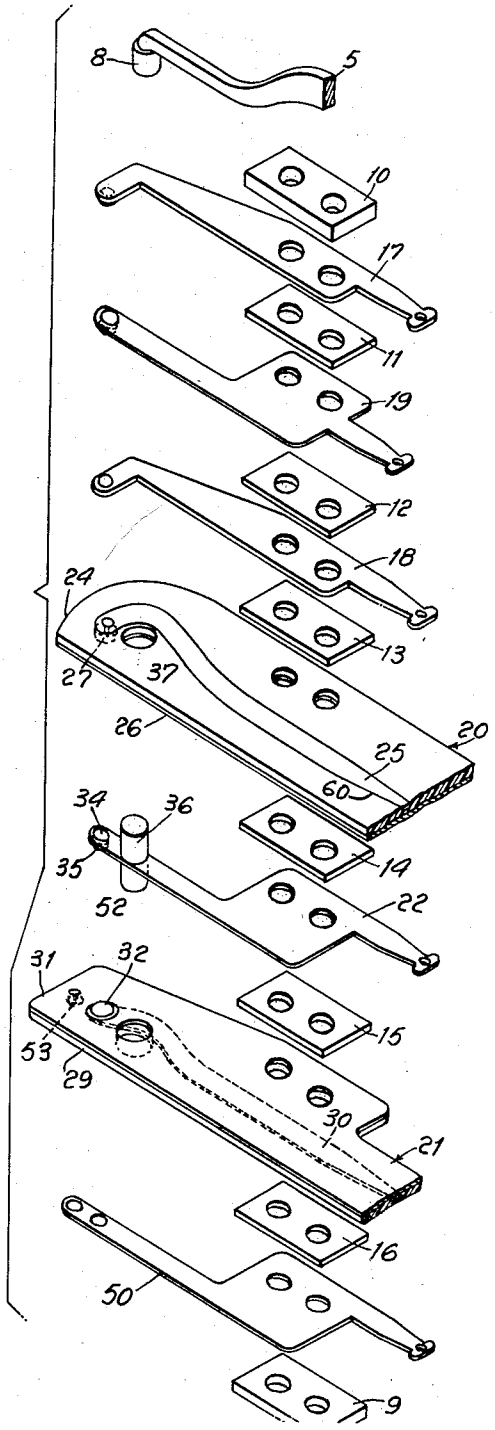
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Fig. 2



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MICROSTRIP SWITCH

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13 Claims. (Cl. 200—104)

This invention relates to electrical switches and more particularly to a high frequency microstrip switch.

Electrical devices for switching from one transmission line to another are extensively used in high frequency transmission systems. At high frequencies, impedance matching of the transmission line to the switching connection and to the switching arrangement within said switch presents serious problems. If a mismatch exists, the standing wave ratio becomes very high and the power losses are large. High frequency relay switches have been devised and are used which employ a relay and a plurality of coaxial connectors, one of which is the common or input transmission line that may be selectively switched to either one of the plural lines by energizing the relay. In the coaxial transmission line the ground is common, therefore, only the inner conductors of the said transmission lines are switched to make the interconnections. These switches require expensive components and are costly to make. Furthermore, the said switches are limited in function to the switching of the high frequency transmission lines and no provision is made in said switches for switching of low frequency circuits or direct current circuitry. If the system requires such switching of low frequency and direct current circuitry, additional switches or relays must be provided.

It is therefore an object of this invention to provide a simplified and inexpensive switching device utilizing microstrip transmission lines. The microstrip transmission system employs usually, two conductors, one as a "ground conductor" and the other as a "line conductor" spaced close together in substantially parallel relation. The so-called "ground conductor" which may be at ground potential or some other given potential, is considerably wider than the line conductor so that the surface thereof provides in effect an image reflection of the line conductor, whereby the distribution of the electric and magnetic fields between the conductors is substantially the same as the distribution between one conductor and the neutral plane of a two-conductor parallel system. Small variations in size and shape of the line conductor may produce variations in the characteristic impedance of the system but the field distribution with respect to the ground conductor is not materially disturbed. Likewise, certain variations in the surface of the ground conductor do not materially disturb the field distribution with respect to the surface thereof since such variations either neutralize each other or do not adversely affect the field distribution between the two conductors. By this system, microwaves can be easily propagated by the TEM mode along the line-ground conductor system since the microwaves flow in the regions of the electromagnetic field bounded substantially by the opposed surfaces of the line and ground conductors.

It is another object of this invention to provide means for switching low frequency circuits and direct current circuits as well as the high frequency transmission line circuits.

A feature of this invention is the adaptation of microstrip transmission line technique to relay switching. Two ground conductors with associated line conductors dielectrically spaced are disposed on opposite parallel sides of a third line conductor. Contacts are coupled to the free end of said line conductors and means are provided to move the third line conductor to selectively engage either of said first and second line conductors.

Another feature is the provision of a spring contact adjacent at least one of the high frequency transmission lines which operates to ground the line conductor when it is not engaged by the third line conductor.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is an elevation view of an embodiment of this invention;

Fig. 2 is an exploded perspective view of the contact arrangement of the high frequency transmission line and the low frequency contact springs of Fig. 1; and

Fig. 3 shows the connection of a coaxial transmission line to one of the microstrip high frequency transmission lines of this invention.

With reference to Fig. 1, there is shown a relay **1** comprising a coil **2**, a soft iron core **3** disposed within said coil **2** and extending beyond the ends thereof, a support bracket **4** on which is mounted securely the said coil **2** and said core **3**. An armature **5** having adjusting screw **6** is movably fastened to said support bracket **4** by pivot **7**. A dielectric stud **8** is secured to the lever end of armature **5**. The contact spring pile up **9** is mounted on said support bracket **4** and insulated therefrom and from each other by dielectric spacers **10**, **11**, **12**, **13**, **14**, **15** and **16**. The contact springs **17** and **18** are conventional relay type fixed springs, contact spring **19** is a conventional relay type movable spring. Microstrip high frequency transmission lines **20** and **21** and the line conductor **22** disposed intermediate said transmission lines **20** and **21** complete the pile up **9**.

Transmission line **20** consists of a flat dielectric strip **24**; line conductor **25** on one side of said strip **24**, and ground plane conductor **26** on the other side. The relative widths of said line conductor **25**, dielectric strip **24** and ground conductor **26**, and the thickness of dielectric strip **24** are determined according to the principles of microstrip transmission line systems hereinabove described. Line conductor **25** is coupled to contact **27** through an opening **28** in ground conductor **26** and dielectric strip **24**. Transmission line **21** is made in a similar manner and according to the same microstrip transmission line principles. On opposite sides of dielectric strip **29** are line conductor **30** and ground conductor **31**; contact **32** is coupled to line conductor **30** through opening **33** in the dielectric strip **29** and ground conductor **31**. The line conductor **22**, made of the same spring metal as movable contact spring **19**, is intermediate transmission lines **20** and **21**, with contacts **34** and **35** disposed on opposite sides of said line conductor **22**. When line conductor **22** is contacting line conductor **25**, a third high frequency transmission line is formed consisting of line conductor **22** and ground conductor **26**; when line conductor **22** contacts line conductor **30**, the third transmission line now consists of line conductor **22** and ground conductor **31**. The dielectric stud **36** mounted on line conductor **22** contacts movable contact spring **19** through opening **37** in dielectric strip **24**, ground conductor **26** and line conductor **25**. Fixed spring **18** is formed to allow stud **37** to bypass it without interference. The dielectric

stud 8 contacts the opposite side of movable spring 19 in axial relation with dielectric stud 36.

In the position shown with the relay coil 2 de-energized, movable spring 19 contacts fixed spring 17 and line conductor 22 contacts line conductor 25 of transmission line 20. When the relay coil 2 is energized, a magnetic field is created magnetizing the core 3. Armature 5 is pulled toward core 3 and stud 8 thereby moves movable contact spring 19 to contact fixed spring 18, and moves stud 37 to break the contact of line conductor 22 with line conductor 25 the contact of line conductor 22 with line conductor 30.

In some switching installations it is desirable to ground the line conductor that is not connected in circuit. For example, the first transmission line A may be coupled to a transmitter, the second transmission line B to a receiver and the third transmission line C to an antenna. When the antenna is switched from the receiver to the transmitter, it is desirable to avoid leakage to the receiver. This is accomplished by grounding the line conductor 30 of the second transmission line B when the third line conductor 22 is moved from engagement with contact 32 to engagement with contact 27. This is done by means of a spring contact 50 which is grounded to an outer conductor at 51. This spring is controlled by stud 52. To further insure a proper ground for line B at the end thereof, the ground conductor 31 is provided with a contact 53 at its extreme end which is adapted to be engaged by spring 50 simultaneously with engagement with line conductor 30. Thus, when contact 32 is disengaged by line conductor 22, the line and ground conductors 30 and 31 are interconnected thus deactivating the line to the receiver. A similar shorting contact could also be provided for the conductors of this first transmission line A, if such were desired.

Referring to Fig. 2 the component parts of the pile up arrangement of the contact springs and the microstrip transmission line of Fig. 1 are shown in isometric perspective. The shape and relative sizes of said component parts are set forth in a more detailed manner to indicate the interfunction of said parts. It will be observed that the microstrip transmission line ground conductor is wider than the associated line conductor. The curved portion of the line conductor 25 circumjacent the opening in dielectric strip 24 and ground plane 26 may produce minor variations in the characteristic impedance of the transmission line but as heretofore explained, the field distribution with respect to the ground conductor is not materially disturbed.

The ground conductors 31 and 26 and the line conductors 25 and 30 may be thin strips of conductive material cemented to the dielectric strips 24 and 29 or may be formed of electro-deposited conductive material directly on the said strips 24 and 29. In that case suitable tabs may be connected to said line conductors 25 and 30 to provide for interconnection with a coaxial transmission line.

Referring to Fig. 3, a means of connecting a typical high frequency coaxial transmission line such as line A to the microstrip high frequency transmission line of this invention is disclosed, which has been successfully applied in a reduction to practice of this invention. The termination of said high frequency coaxial transmission line A is prepared for connection in the conventional manner. A metal clamp 39 shaped to fit the curvature of the said coaxial line A is placed over the shield or outer conductor 40 of said coaxial line. The straight portion of said metal clamp 39 is positioned against the ground conductor 26. Solder is now applied to the clamp 39, transmission line shield 40 and the ground conductor 26. The inner conductor 41 of coaxial line A is then soldered to the line conductor 25 which is tapered at 60 to the diameter of the inner conductor. The resulting connection forms a strong mechanical and electrical coupling of the coaxial line A to the high frequency transmission line 20. It will be understood, of course, that other high frequency waveguides may be employed in the place of the coaxial lines A, B and C, if desired. Where the distance is relatively short from the switch to such units as the transmitter, receiver or antenna, the microstrip line of the switch may be continued from the switch to such unit.

It is to be understood that the pile up arrangement as described above is by way of illustration only and may be varied by increasing the number of contact springs and microstrip transmission lines along both the vertical and horizontal axes as may be necessary.

While we have described above the principles of our invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of our invention as set forth in the objects thereof and in the accompanying claims.

We claim:

1. A switching device for use with high frequency energy comprising a high frequency transmission line including a first line conductor, a ground conductor and a strip of dielectric material supporting said first and second conductors on opposite sides thereof throughout substantially the entire lengths of said conductors, the ground conductor being wider than said first line conductor to present thereto a laterally extended conducting surface and said dielectric strip being thin to thereby dispose the said conductors in relatively close spaced parallel relation for propagation of high frequency energy in a mode approximating the TEM mode, a contact coupled to said first line conductor, said contact being externally disposed relative to said ground conductor, a second line conductor in spaced parallel relation to said ground conductor and forming therewith a second high frequency transmission line, said ground conductor being intermediate said first and second line conductors and means for moving said second line conductor to engage or disengage the said contact of said first line conductors.

2. A switching device according to claim 1, wherein said ground conductor and said dielectric strip have an opening therethrough and the contact coupled to said first line conductor is disposed through said opening for switching engagement with said second line conductor.

3. A switching device for use with high frequency energy comprising a high frequency transmission line including a first line conductor and a ground conductor, the ground conductor being wider than said first line conductor to present thereto a laterally extended conducting surface and means disposing the said conductors in dielectrically spaced parallel relation for propagation of high frequency energy in a mode approximating the TEM mode, a contact coupled to said first line conductor, said contact being externally disposed relative to said ground conductor, a second line conductor in spaced parallel relation to said ground conductor and forming therewith a second high frequency transmission line, said ground conductor being intermediate said first and second line conductors and means for moving said second line conductor to engage or disengage the said contact of said first line conductors, said means for moving said second line conductor being electromagnetic means comprising an energizing coil, a magnetically permeable core disposed within said coil and extending beyond both ends of said coil, a support bracket, means coupling one end of said coil and said core to said support bracket, an armature disposed opposite the unsupported end of said coil and said core, pivot means coupling said armature to said support bracket and adapted to allow movement of said armature toward said core when said coil is energized, dielectric means coupling said first and second line conductors and said first ground conductor to said support bracket, a dielectric stud, means coupling said stud to said armature, said stud contacting said second line conductor and adapted to move said second

line conductor to engage or disengage the said contact of said first line conductor, when said coil is energized.

4. A switching device for use with high frequency energy comprising a first high frequency transmission line having a first line conductor and a first ground conductor and a strip of dielectric material supporting said first line conductor and said first ground conductor on opposite sides thereof throughout substantially the entire lengths of said first conductors, a second high frequency transmission line having a second line conductor and a second ground conductor and a strip of dielectric material supporting said second line conductor and said second ground conductor on opposite sides thereof throughout substantially the entire lengths of said second conductors, each ground conductor being wider than its associated line conductor to present thereto a laterally extended conducting surface, and said dielectric strips being thin to thereby dispose the said line and ground conductors of each transmission line in relatively close spaced parallel relation for propagation of high frequency energy in a mode approximating the TEM mode, said first and second ground conductors being disposed in spaced parallel relation, a contact coupled to each of said line conductors, each said contact being externally disposed relative to the associated ground conductor, and a third line conductor disposed intermediate said ground conductors and forming therewith a third high frequency transmission line, and means for moving said third line conductor to engage selectively said contacts of said first and second line conductors.

5. A switching device according to claim 4, wherein each of said ground conductors and said dielectric strips has an opening therethrough and the contacts coupled to said first and second line conductors are disposed respectively in these openings for switching action with respect to said third line conductor.

6. A switching device for use with high frequency energy comprising a first high frequency transmission line having a first conductor and a first ground conductor, a second high frequency transmission line having a second line conductor and a second ground conductor, each ground conductor being wider than its associated line conductor to present thereto a laterally extended conducting surface, and means disposing the said line and ground conductors of each transmission line in dielectrically spaced parallel relation for propagation of high frequency energy in a mode approximating the TEM mode, said first and second ground conductors being disposed in spaced parallel relation, a contact coupled to each of said line conductors, each said contact being externally disposed relative to the associated ground conductor, and a third line conductor disposed intermediate said ground conductors and forming therewith a third high frequency transmission line, and means for moving said third line conductor to engage selectively said contacts of said first and second line conductors, said first, second and third transmission lines are coupled respectively to first, second and third coaxial lines, the outer conductors of all said coaxial lines being electrically connected to said ground conductors and the inner conductors of said first, second and third coaxial lines being coupled respectively to the line conductors of said first, second and third transmission lines.

7. A switching device according to claim 4, further including means to ground said second line conductor when said third line conductor engages said first line conductor.

8. A switching device according to claim 7, wherein the last named means includes a shorting conductor movable with said third line conductor, when said third line conductor is moved to engage said first line conductor, to interconnect said second line conductor to said second ground conductor.

9. A switching device for use with high frequency energy comprising a first high frequency transmission

line having a first line conductor and a first ground conductor, a second high frequency transmission line having a second line conductor and a second ground conductor, each ground conductor being wider than its associated line conductor to present thereto a laterally extended conducting surface, and means disposing the said line and ground conductors of each transmission line in dielectrically spaced parallel relation for propagation of high frequency energy in a mode approximating the TEM mode, said first and second ground conductors being disposed in spaced parallel relation, a contact coupled to each of said line conductors, each said contact being externally disposed relative to the associated ground conductor, and a third line conductor disposed intermediate said ground conductors and forming therewith a third high frequency transmission line, and means for moving said third line conductor to engage selectively said contacts of said first and second line conductors, said means for moving said third line conductor being electromagnetic means comprising an energizing coil, a magnetically permeable core disposed within said coil and extending beyond both ends of said coil, a support bracket, means coupling one end of said coil and said core to said support bracket, an armature disposed opposite the unsupported end of said coil and said core, pivot means coupling said armature to said support bracket and adapted to allow movement of said armature toward said core when said coil is energized, dielectric means coupling said first and second ground conductors and said first, second and third line conductors to said support bracket, a dielectric stud, means coupling said stud to said armature, said stud contacting said third line conductor and adapted to move said third line conductor for said selective engagement with said contacts of said first and second line conductors when said coil is energized.

10. A switching device for use with high frequency energy and low frequency energy comprising first and second high frequency transmission lines each including a line conductor and a ground conductor, the ground conductor being wider than said line conductor to present thereto a laterally extending conducting surface, and means disposing the said conductors in dielectrically spaced parallel relation for propagation of high frequency energy in a mode approximating the TEM mode, the ground conductors of said first and second transmission lines being disposed in spaced parallel relation, a contact coupled to each of said line conductors, said contact being externally disposed relative to the associated ground conductor, a third line conductor disposed intermediate said ground conductors and forming therewith a third high frequency transmission line, a plurality of fixed contact springs, a movable spring disposed in spaced parallel relation intermediate said fixed contact springs, dielectric means spacing said movable spring and said fixed contact springs, and means for moving said third line conductor to engage selectively said contacts of said first and second line conductor, said means moving coincidentally said movable contact spring to engage selectively said fixed contact springs.

11. A switching device according to claim 10, wherein said means for moving said third line conductor and for moving said movable contact spring are electromagnetic means comprising an energizing coil, a magnetically permeable core disposed within said coil and extending beyond both ends of said coil, a support bracket, means coupling one end of said coil and said core to said support bracket, an armature disposed opposite the unsupported end of said coil and said core, pivot means coupling said armature to said support bracket and adapted to allow movement of said armature toward said core when said coil is energized, dielectric means coupling said first and second ground conductors and said first, second and third line conductors to said support bracket, a first dielectric stud, means coupling said first stud to

said third line conductor, said first stud contacting said movable contact spring, dielectric means coupling said fixed contact springs and said movable contact spring to said support bracket, a second dielectric stud, means coupling said second stud to said armature, said second stud contacting said movable contact spring and adapted to move said movable contact spring for selective engagement with said fixed contact springs and to move coincidentally said third conductor for selective engagement with said contacts of said first and second line conductors when said coil is energized.

12. A switching device for use with high frequency energy and with low frequency energy comprising a high frequency transmission line consisting of a first line conductor and a ground conductor, the ground conductor being wider than said first line conductor to present thereto a laterally extended conducting surface, and means disposing the said conductors in dielectrically spaced parallel relation for propagation of high frequency energy in a mode approximating the TEM mode, a contact coupled to said first line conductor, said contact being externally disposed relative to the ground conductor, a second line conductor in spaced parallel relation to said ground conductor and forming therewith a second high frequency transmission line, said ground conductor being intermediate said first and second line conductors, a plurality of fixed contact springs, a movable contact spring disposed in spaced parallel relation intermediate said fixed contact spring, dielectric means spacing said movable spring and said fixed contact springs, and means for moving said second line conductor to engage or disengage the said contact of said first line conductor and for moving coincidentally said movable contact spring to engage selectively said fixed contact springs.

13. A switching device according to claim 12, wherein said means for moving said third line conductor are electromagnetic means comprising an energizing coil, a magnetically permeable core disposed within said coil and extending beyond both ends of said coil, a support bracket, means coupling one end of said coil and said core to said support bracket, an armature disposed opposite the unsupported end of said coil and said core, pivot means coupling said armature to said support bracket and adapted to allow movement of said armature toward said core when said coil is energized, dielectric means coupling said first and second line conductors and said ground conductors to said support bracket, a first dielectric stud, means coupling said first stud to said second line conductor, said first stud contacting said movable contact spring, dielectric means coupling said movable spring and said fixed contact springs to said support bracket, a second dielectric stud, means coupling said second dielectric stud to said armature, said second stud contacting said movable contact spring and adapted to move said movable contact spring to engage selectively said fixed contact springs and to move coincidentally said second line conductor to engage or disengage said first line conductor when said coil is energized.

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