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HIGH-FREQUENCY SWITCH

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Fig. 1.

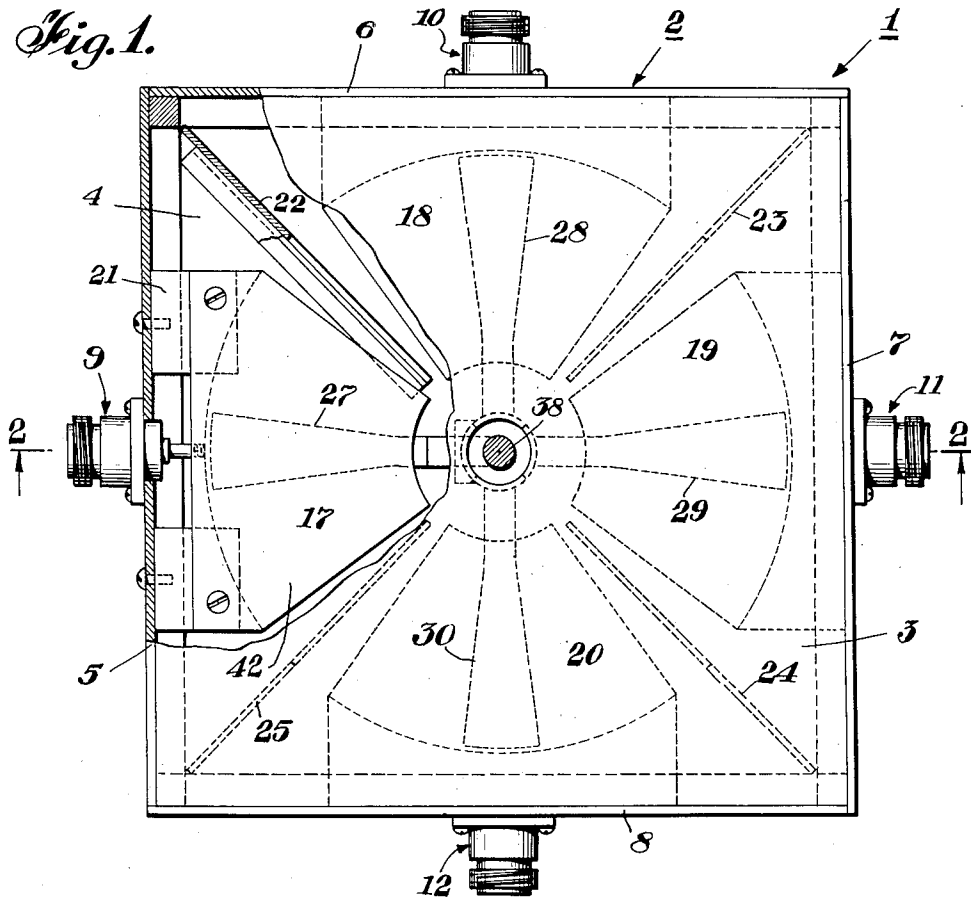


Fig. 2.

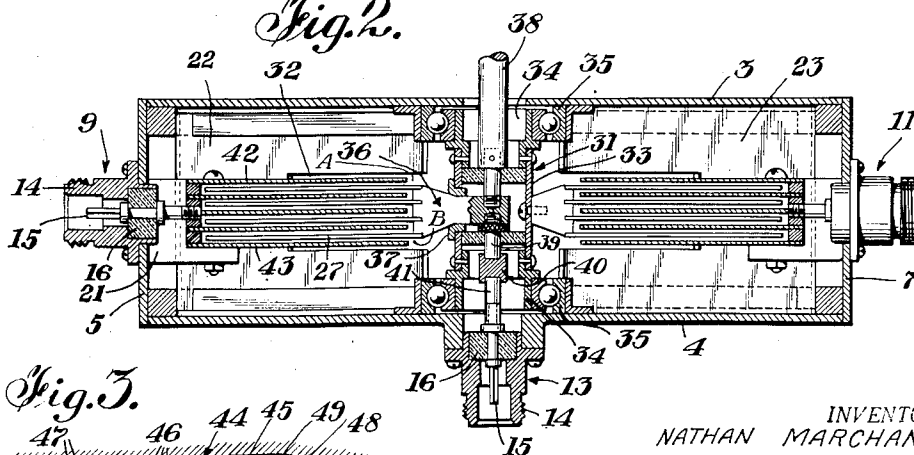
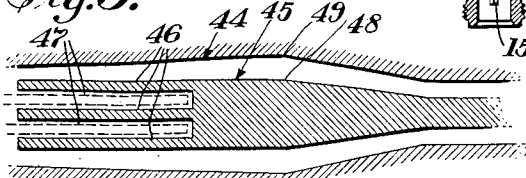


Fig. 3.



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HIGH-FREQUENCY SWITCH

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This invention relates to a mechanically-operated switch for high frequency currents.

An object of the present invention is the provision of an improved form of mechanically-operated switch for high frequency use.

In switching operations the transfer of energy between one transmission line and a selected one of a plurality of other transmission lines may be accomplished by capacitatively coupling the two lines. With higher frequencies, however, capacitive coupling proves inadequate because it tends to give low transfer efficiency, particularly where a wide band of frequencies is to be covered. In accordance with my invention switching is accomplished by the use of transmission line coupling.

Therefore an object of the present invention is the provision of a switch employing transmission line coupling.

Another object of the present invention is the provision of a switch of the type indicated having high transfer efficiency over a relatively wide band.

A feature of the present invention is, particularly in one form thereof, that the switch introduces little change in the surge impedance of the transmission lines over a relatively wide band.

Another object of the present invention is the provision of an improved switch for sequentially coupling one transmission line to each of a plurality of transmission lines, in which interaction between said plurality of transmission lines is kept to a minimum.

Another feature of the present invention is the continuity of the outer shielding of the transmission lines through the switch.

Another object of the present invention is the provision of a switch of the type hereinabove indicated which is particularly adapted for continuous switching. Such switch finds particular applicability in direction finding equipment where it may be used to sequentially couple a plurality of antennas to the direction finding receiver.

A further feature of the present invention is the compactness of the switch and the ease with which it may be manufactured.

Still other features of the present invention are that the switch does not depend for its operation on wiping contact, has little friction, and is quiet and smooth in operation.

Other and further objects and advantages of the present invention will become apparent and the foregoing will be best understood from the following description of embodiments thereof, reference being had to the drawing, in which:

Fig. 1 is a plan view, partly in outline and partly broken away, of one embodiment of my invention;

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Fig. 2 is a transverse sectional view taken along the line 2-2 of Fig. 1;

Fig. 3 is a schematic cross-sectional sketch of a portion of a switch, illustrating a modified form of my invention.

Referring now particularly to the embodiment illustrated in Figs. 1 and 2, the switch referred to generally by the numeral 1 includes a generally rectangular housing similarly referred to generally by the numeral 2 and consisting of a top 3, a bottom 4, and side walls 5-8. The housing is preferably metallic and shields the inside of the switch, being electrically effectively completely closed.

In the embodiment illustrated, the switch is designed to sequentially connect each of four transmission lines to a fifth line. The switch is therefore provided with four sockets 9-12 symmetrically arranged on side walls 5-8 respectively, each of which is adapted to be connected to one of said four transmission lines, and a fifth socket 13 mounted on the bottom 4, which latter socket is adapted to be connected to said fifth transmission line. These sockets are of known construction and are connected by plugs of known construction to their transmission lines. Sockets 9-12 may be the input, and socket 13 may be the output or socket 13 may be the input and sockets 9-12 the output. However, for the purpose of distinguishing the sockets, sockets 9-12 will be referred to as the "input sockets" and socket 13 as the "output socket."

Each of said sockets consists of an outer portion 14 and an inner conductor 15. The outer portions 14 of all of said sockets are connected to the housing 2 and are consequently at a common neutral or ground potential. The inner conductors 15 of the sockets are insulated from the housing by insulators 16.

The inner conductors 15 of the input sockets 9-12 are connected respectively to separate sets of stator plates 17-20, the plates of each of said sets being metallic, horizontally disposed, and spaced apart. Each of said sets is supported by suitable insulating members 21. The stator plates are substantially in the form of sectors of about 70° each in the embodiment illustrated and are symmetrically distributed about a central axis. To prevent interaction between the various stator plates and consequently the transmission lines coupled to their associated sockets, I prefer to provide a plurality of radial or diagonally-arranged shields 22-25 between said plates. For each of the sets of stator plates there is provided a set of rotor plates designated by the numerals 27-30, the sets of rotor plates being likewise symmetrically disposed about a central axis. The rotor plates are metallic, are interleaved with the stator plates but spaced therefrom, and are mounted for rotation on a central rotatable member 31.

In the embodiment illustrated, each set of rotor plates is substantially in the form of a sector of about 15°. To enable the rotor plates to pass between the shields 22-25, each of the shields 22 is cut away as indicated at 32 or the shields may be made with teeth between which the rotor plates pass.

One set of rotor plates 27 is used to sequentially couple the sets of stator plates to the output socket 13. The other sets of rotor plates 28-30 couple to ground, those sets of stator plates which, at a given moment, are not coupled to socket 13, thereby preventing undesirable interaction between the set of stator plates coupled to socket 13 and the remaining sets of plates. For this purpose, the sets of rotor plates 28-30 are electrically connected to, as well as supported from, a metallic collar 33 forming part of the central rotatable member 31. The collar 33 is connected at opposite ends to metallic end pieces 34 which in turn are electrically connected through roller-bearing arrangements 35, which rotatably support the entire rotatable member 31, to the top and bottom of the housing and consequently to ground. Of course it is to be understood that the sets of rotor plates 28-30 may, if desired, be omitted.

The plates of rotor set 27 are mounted on a metallic support member 36 which passes through an insulator 37 into the center of the central rotatable member 31 and is there mechanically connected to a shaft 38 preferably of insulating material, which shaft 38 is adapted to be rotated and thereby cause rotation not only of rotor plates 27 but also of the entire central rotatable member 31 and consequently of the other sets of rotor plates 28-30. The metallic support member 36 is electrically connected through a rotatable metallic rod 39, and a freely rotatable metallic connector 40 to a non-rotating metallic member 41 which is in turn connected to the inner conductor 15 of the socket 13 and, if desired, may be integral with said inner conductor 15.

While the switch may be operated by manually rotating shaft 38, the switch here shown is capable of being operated at a relatively high rate of speed and for this purpose shaft 38 may be connected to any suitable motor. The ratio between the width of the rotor sectors and the width of the stator sectors is dependent on the rate of rotation of the switch. The ratio here shown, which is approximately of the order of 4 to 1, more specifically $4\frac{2}{3}$ to 1, as angularly measured, is suitable for switching between 100 to 300 R. P. M. Of course it is to be understood that the rotor plates may be made as wide as possible to obtain the maximum transfer of energy, but the rate of switching tends to limit this width.

While the construction and arrangement of the plates here is similar to that in a condenser, in accordance with the present invention, transmission line coupling, not capacitance coupling, is used. It will be recognized that the high frequency current flowing in through any of the sockets 9-12 will tend to travel from said socket along the outer surfaces of the top plate 42 and bottom plate 43 of each set of stator plates. At points A and B, this high frequency current might flow over from the stator plates to the rotor plates if certain transmission line conditions were met. It will be seen, looking inwardly between the plates from points A or B, that the surfaces of the stator and rotor plates opposing or facing each other may be considered

as similar to an open-ended dual transmission line of which the surfaces of the stator plates form one conductor and the surfaces of the rotor plates form the other conductor. As viewed from point A, if the length of said line, which is the common length of the opposing surfaces of the stator and rotor plates as radially measured is made equal to a quarter wavelength or an odd integral multiple thereof, there will be an effective short at point A permitting transfer of energy from the stator to the rotor plates at said point. Similarly if the same conditions prevail at point B, we would have an effective short at point B. It will therefore be seen that to satisfy both of said conditions, it is necessary that the total electrical length of the line, that is the common length of said opposing surfaces of the rotor and stator plates from point A to point B, be equal to two quarter wavelength sections or one-half wavelength. This is true since the midpoint of a transmission line which is fed with equal voltages into both its ends may be considered open circuited.

Since, however, the switch is designed to be operated over a relatively wide band of frequencies, the total common length of the opposing surfaces of the stator and rotor plates measured from point A to point B is made equal to a half wavelength at the mean frequency of the band. This relationship holds true and in accordance with this invention is incorporated in the switch whether only one stator and one rotor plate are coupled together or whether a plurality of either or both are coupled together. The number of rotor and stator plates employed and the radial length of said plates is determined by the frequencies at which the switch is to be operated and by the desired compactness of the arrangement, the effective total electrical length of said rotor and stator plate surfaces being a function of the product of the length of the plates times the number of said plates.

A switch made in accordance with the foregoing description and designed for high frequency operation over a three to one band width gave a transfer efficiency of from 60% to 80%. The width of the plates is a prime factor in determining the width of the band of frequencies that may efficiently be covered with such a switch.

Referring now to the modification shown in Fig. 3 which shows a portion of a modified form of switch embodying the present invention, numeral 44 designates the housing and numeral 45 designates a conductor within the housing. The conductor 45 corresponds to a set of stator plates such as illustrated in Figs. 1 and 2 and for this purpose may consist of a single surface or may be cut away to form a plurality of stator plates 46 which are to be coupled to a plurality of rotor plates 47 (indicated in dotted lines). The stator plates 46 are substantially in the form of a sector similar to the sectors of the stator plates in Figs. 1 and 2. The arc of said sector or widest portion of said conductor 45 occurs at point 48. To maintain a constant surge impedance, the housing 44 is so shaped that at the point 49 thereof, opposite point 48 of conductor 45, it is most widely spaced from said conductor 45. As the width of the sector of conductor 45 decreases, the spacing between the housing 44 and said conductor also decreases and thus the surge impedance is constant along the common opposing surfaces of conductor 45 and housing 44. This relationship between the housing and the stator plates and its associated conductor may be main-

tained throughout the whole switch, only a portion of said switch here being illustrated. With the impedance substantially matched, even greater efficiency of transfer than in the forms shown in Figs. 1 and 2 is obtained.

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

I claim:

1. A high frequency switch comprising a plurality of terminals, a plurality of sets of metallic stator plates, each set connected to one of said terminals, a plurality of separate sets of metallic movable plates each set of which is adapted to be simultaneously coupled to separate ones of said sets of stator plates, each of said sets including at least one plate, means for simultaneously moving each of said sets of movable plates out of coupling relation with the set of stator plates to which it has been coupled and into coupling relation with another of said sets of stator plates, the effective circuitous electrical length of the opposing surface of the plates of each pair of coupled stator and movable sets being substantially equal to half a wave length at the mean frequency of the band over which said switch is designed to operate, one set of said movable plates being connected to a separate one of said terminals, the other of said sets of movable plates being connected to ground.

2. A high frequency switch comprising a plurality of terminals, a plurality of sets of metallic stator plates each connected to one of said terminals, a plurality of sets of metallic rotor plates, one of said sets of rotor plates connected to a separate one of said terminals and the other of said sets of rotor plates connected to ground, each of said sets including at least one plate, said sets of stator and rotor plates being symmetrically disposed around a central axis, said sets of rotor plates being mounted for rotation around said central axis so that upon rotation the rotor plates of each set will sequentially interleave with the plates of each set of stator plates to thereby move said plates into and out of coupling relation with each other, the effective circuitous electrical length of the opposing surfaces of the plates of each pair of coupled stator and rotor sets being substantially equal to half a wave length at the mean frequency of the band over which said switch is designed to operate.

3. A high frequency switch comprising a metallic housing, a plurality of terminals, a set of metallic stator plates mounted within said housing and connected to one of said terminals, a set of metallic movable plates connected to another of said terminals, each of said sets including at least one plate, and means for moving said set of movable plates into and out of coupling relation with said set of stator plates, said stator plates being substantially in the form of a sector of a circle, said housing having portions extending over said plates, said portions being spaced from the arc of said sector a greater distance than from the apex of said sector to thereby maintain a substantially constant surge impedance along the common opposing surfaces of said set of stator plates and said housing.

4. A high frequency switch comprising a metallic housing, a plurality of terminals extending outwardly through said housing, a plurality of sets of metallic stator plates symmetrically disposed within said housing around a central axis and each connected to one of said terminals, a set of metallic rotor plates mounted within said housing for rotation around said central axis and adapted to interleave with said stator plates during said rotation to thereby move said plates into and out of coupling relation with each other, said set of rotor plates being connected to a separate one of said terminals, each of said sets including at least one plate, a plurality of shields connected to said housing and extending radially between each of said sets of stator plates and having openings therein for the passage of the rotor plates therethrough and further including at least one other set of rotor plates mounted for simultaneous rotation with said first-mentioned set of rotor plates around said central axis, the number of sets of rotor plates being equal to the number of sets of stator plates and being similarly symmetrically disposed around said central axis, said other set of rotor plates being similarly adapted to be coupled to each of said sets of stator plates and being electrically connected to the housing.

5. A high frequency switch comprising a metallic housing, a plurality of terminals extending outwardly through said housing, a plurality of sets of metallic stator plates symmetrically disposed within said housing around a central axis and each connected to one of said terminals, a set of metallic rotor plates mounted within said housing for rotation around said central axis and adapted to interleave with said stator plates during said rotation to thereby move said plates into and out of coupling relation with each other, the effective circuitous electrical length of the opposing surfaces of one set of said stator plates and said rotor plates when in coupled relation being substantially equal to half a wave length at the mean frequency of the band over which said switch is designed to operate, said set of rotor plates being connected to a separate one of said terminals, each of said sets including at least one plate, a plurality of shields connected to said housing and extending radially between each of said sets of stator plates and having openings therein for the passage of the rotor plates therethrough, at least one other set of rotor plates mounted for simultaneous rotation with said first-mentioned set of rotor plates around said central axis, the number of sets of rotor plates being equal to the number of sets of stator plates and being similarly symmetrically disposed around said central axis, said other set of rotor plates being similarly adapted to be coupled to each of said sets of stator plates and being electrically connected to the housing.

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