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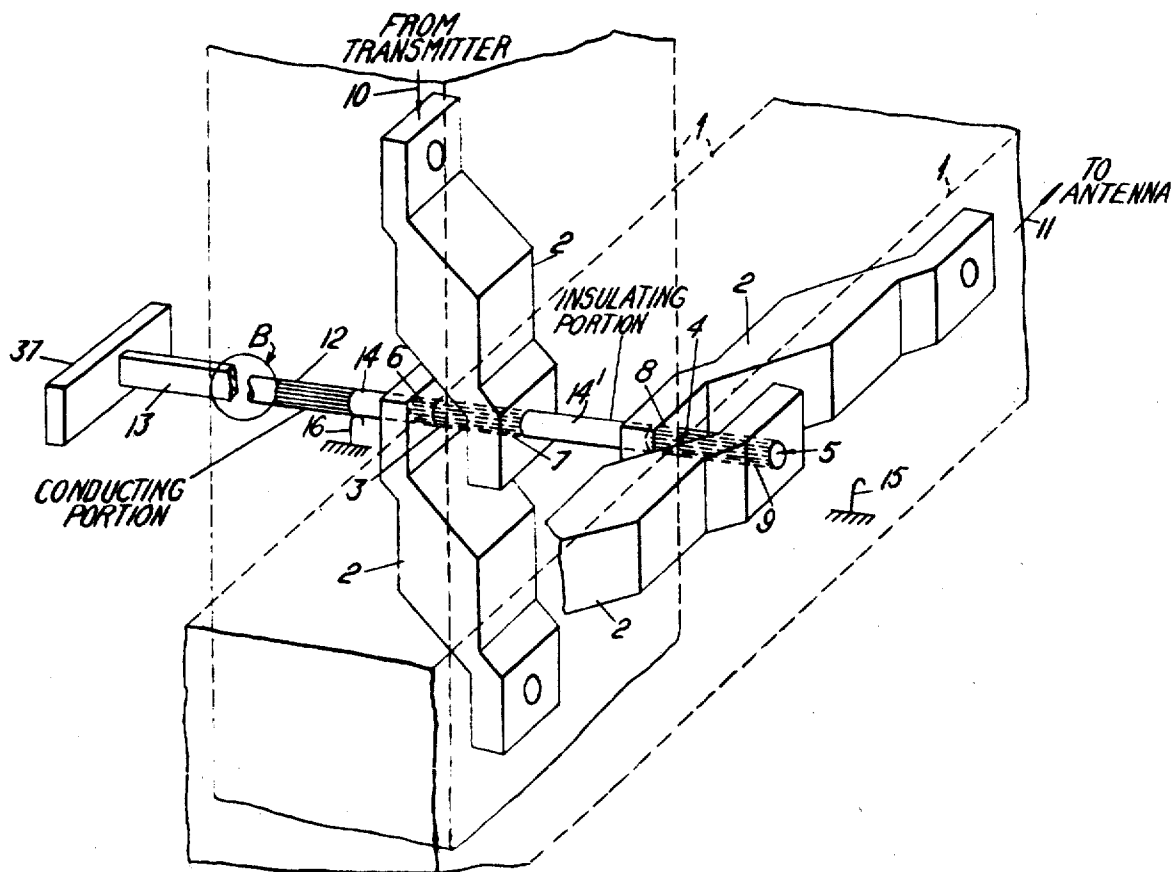
[54] **ANTENNA SWITCHING EXCHANGE**
8 Claims, 7 Drawing Figs.

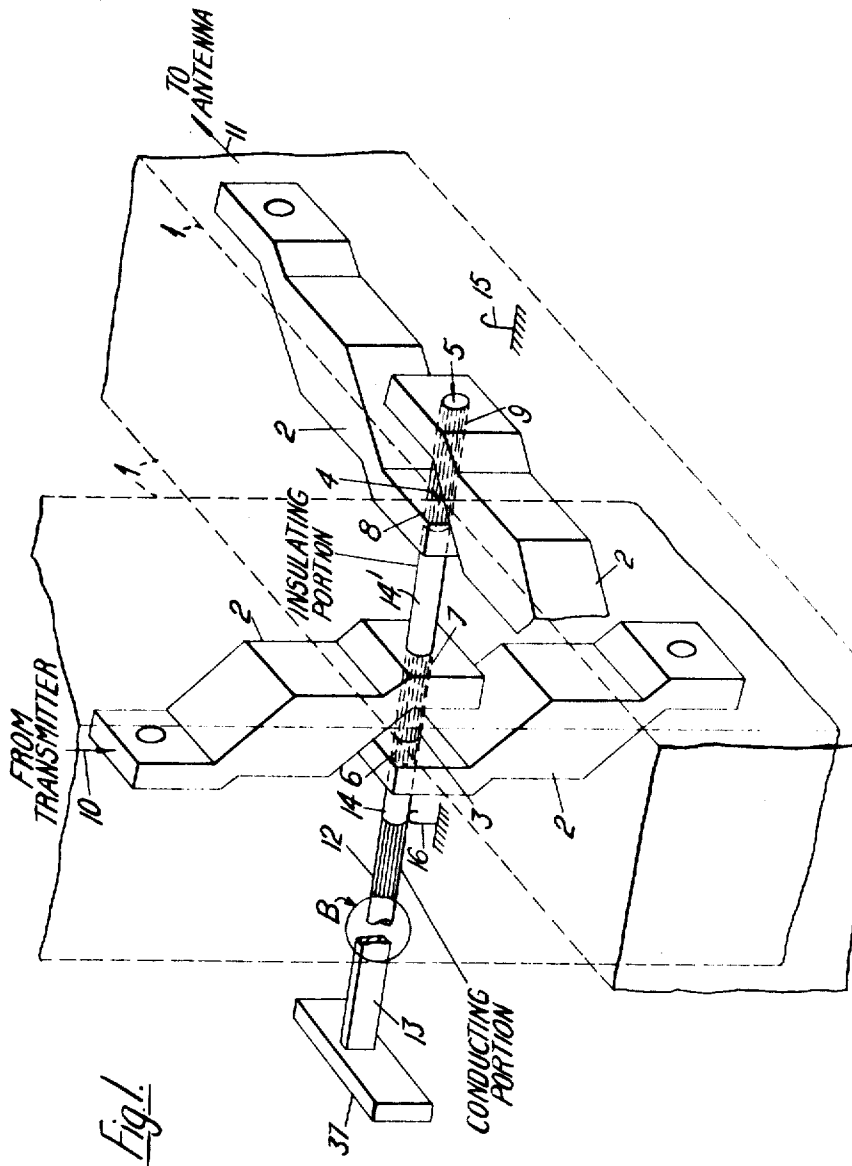
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[56] **References Cited**

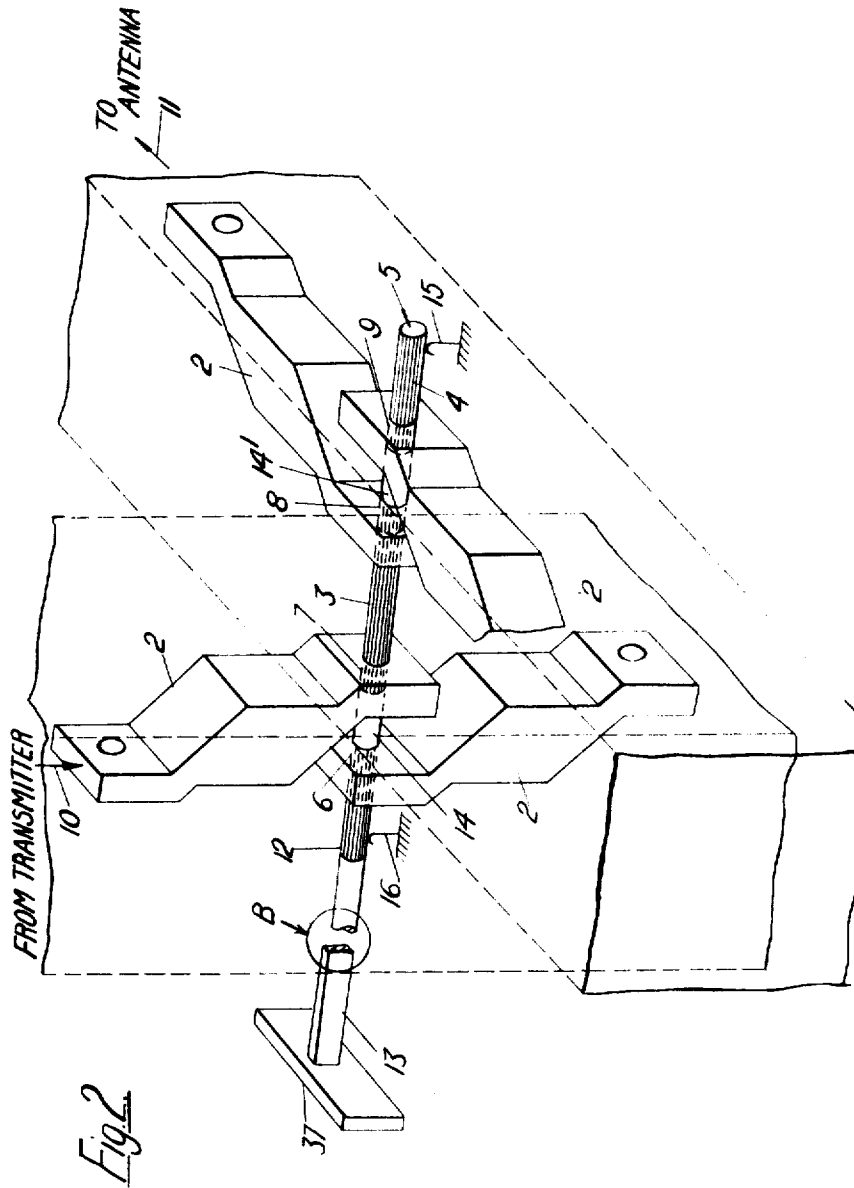
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ABSTRACT: A switching matrix including an orthogonal array of $m \times n$ coaxial lines, where m equals the number of transmitters which may be simultaneously connected to the matrix and n is the number of antennas to each of which any one of the m transmitters may be connected. Each of the n rows is made up of m separated sections of a coaxial line center conductor connected electrically by first conducting contacts at each cross-point of the matrix. Each of the m columns is made up of n separated sections of a coaxial line center conductor connected electrically by second conducting contacts at each cross-point of the matrix. The first and second conducting contacts for each cross-point are a part of a common rod separated by segments of insulating material. A cross-point through connection is established by movement of the rod so as to connect the row to the column by relocation of the second conducting contact. Simultaneously the remaining length of the row and column are automatically grounded by the first conducting contact and a third conducting contact separated by insulating material from the second conducting contact to eliminate the presence of residual stubs in the matrix. A cam assembly to make and break the cross-point through connection is coupled to either all the rods of a column or all the rods of a row depending upon which has the lesser number of rods. A single motor drives the cam assembly.

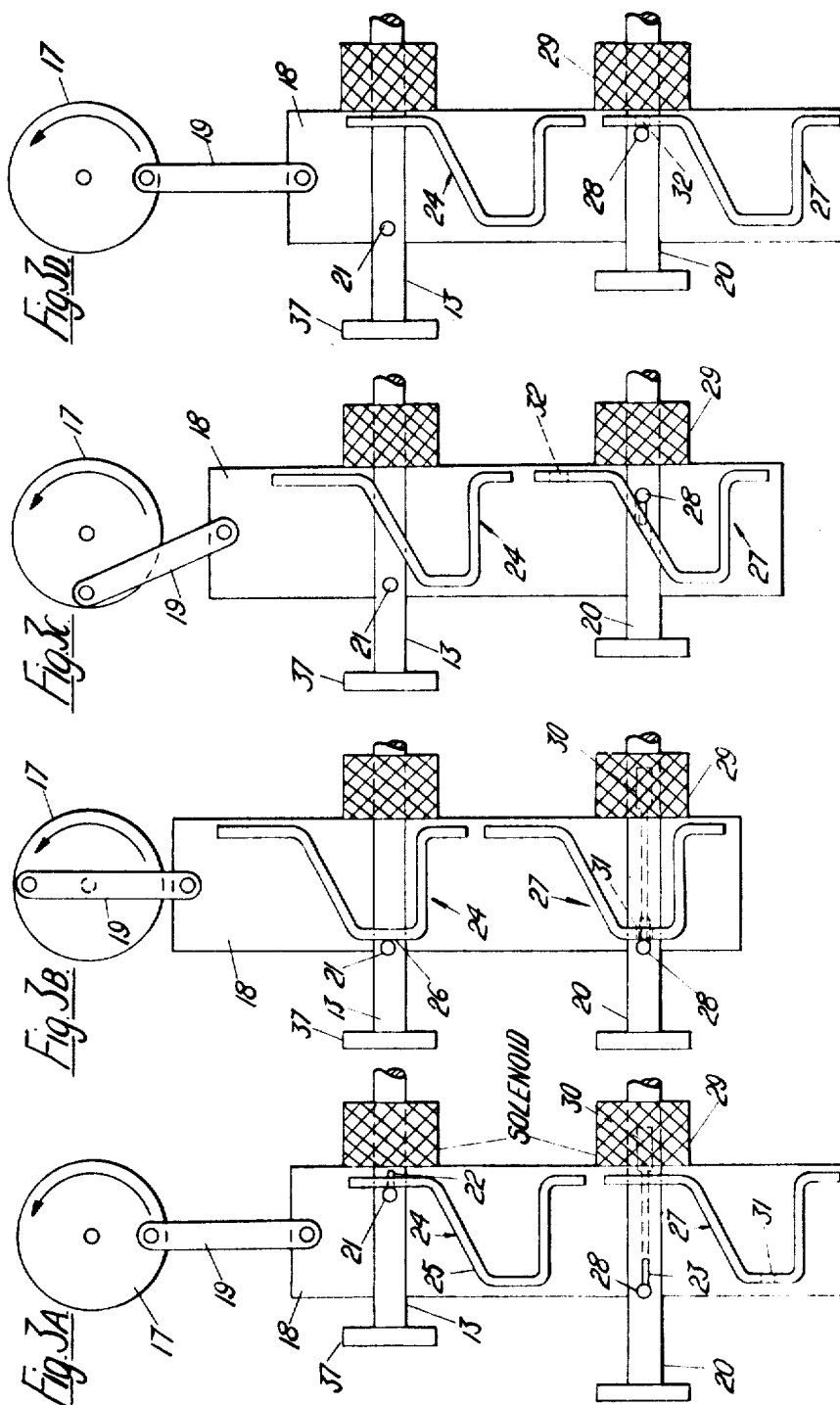




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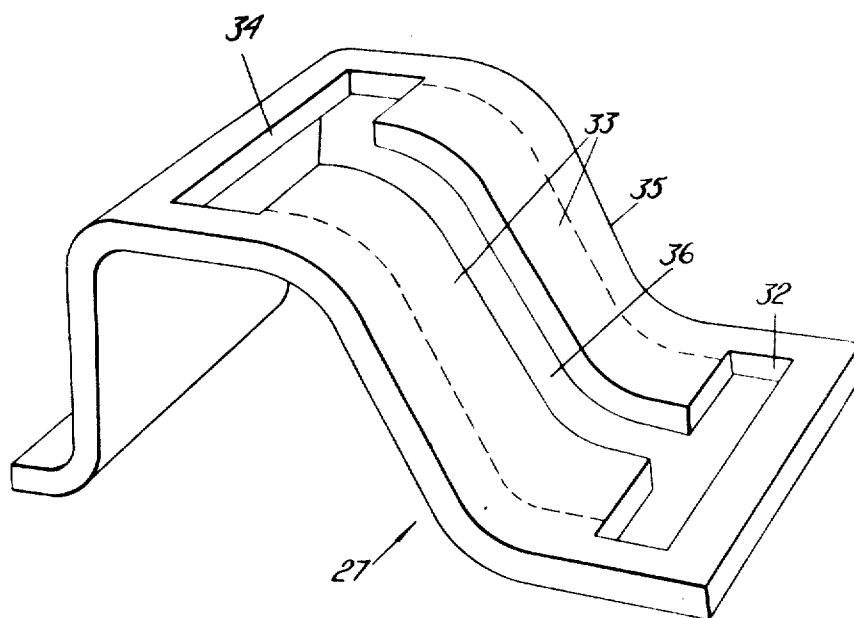


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Fig. 4



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ANTENNA SWITCHING EXCHANGE

BACKGROUND OF THE INVENTION

The invention relates to the field of antenna switching exchanges and in particular to antenna switching exchanges in which it is required to switch one of a plurality of transmitters to a particular one of a plurality of antennas.

In the field of radio communications there is a growing need for the fast, reliable switching of high powered transmitters to a selection of antennas not only in commercial applications, such as in broadcast radio and television transmission, but also, and particularly, in military and space communication facilities where complete flexibility between large numbers of transmitters and antennas is required with minimum time for the switching process.

Design considerations for antenna exchanges include the following features which are desirable, and in some cases essential, requirements of the exchanges concerned.

1. A minimum number of moving parts and contact surfaces;
2. the involvement of the least possible number of cross-points to achieve the desired RF power transfer;
3. low level complexity of each number of active devices used (such as drive motors);
4. protection against the occurrence of multiple connections between transmitters, antennas or both;
5. the removal of RF power from the exchange circuits prior to switching;
6. automatic indication of circuit setup in operation;
7. the remote controllability of exchange switching combinations;
8. the manual operations of exchange cross-points in case of failure of the remote control system or drive motors;
9. the removal of residual stubs within the operated circuits to prevent RF short circuits occurring;
10. the minimum interaction or crosstalk between adjacent rows and columns of transmission lines within the exchange proper; and
11. ease of replacement of components and ready adaptability for future expansion of the system.

Known antenna exchange constructions do not possess all these features and it is found that, where some of the more important features are obtained, the high degree of operational efficiency required by the modern telecommunications art cannot be met.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an antenna switching exchange capable of providing all of the above-mentioned features, and in some respects exceed the currently accepted standards and parameters of performance.

Another object of the present invention is to provide an antenna switching matrix for handling RF (radio frequency) power which is remotely and automatically operable and which also has provision for manual operation if required, for instance, in the case of failure of the automatic control system.

A feature of the present invention is the provision of an antenna switching exchange comprising an orthogonal array of m input coaxial lines and n output coaxial lines having $m \times n$ cross-points between the input and output lines, where m and n are integers greater than one; each of the m input lines including an inner conductor having n separated sections, each of the n sections being disposed between different adjacent ones of the cross-points; each of the n output lines including an inner conductor having m separated sections, each of the m sections being disposed between different adjacent ones of the cross-points; $m \times n$ longitudinally movable rods each associated with a different one of the cross-points; each of the rods including at least a first and a second conducting portion separated by a first insulating portion; each of the first conducting portions electrically connecting different adjacent ones of the n sections and each of the second conducting por-

tions electrically connecting different adjacent ones of the m sections when the rod is moved to prevent a through connection for its associated one of the cross-points; each of the second conducting portions disconnecting different adjacent ones of the m sections, each of the first conducting portions disconnecting a different adjacent ones of the n sections and each of the second conducting portions connecting one of the adjacent ones of the m sections to one of the adjacent ones of the n sections when the rod is moved to establish a through connection for the associated one of the cross-points; and an arrangement coupled to each of the rods for longitudinal movement thereof.

In essence the invention comprises an m by n orthogonal array or matrix of coaxial transmission lines, where m is the number of transmitters which may be simultaneously introduced to the exchange and n is the number of antennas to each of which any one of the m transmitters may be connected. If $m > n$, then at one end of each of the n rows of lines is drive means to control the switching arrangement and enable RF power from the input of that row to be fed via an appropriate cross-point of the array or matrix to a preselected antenna through its associated column of the m transmission lines. If, however, $m < n$, then the drive means will be associated with each of the m columns of the matrix.

Each of the n rows is made up of m sections of coaxial transmission line linked one to the other by conducting contacts at each cross-point. Each of the m columns of the matrix is made up of n sections of coaxial transmission line, each section also linked to its adjacent section by conducting contacts at the cross-point. The conducting contacts for both the columns and rows of lines are provided by a rod passing through each of the two linked sections. The two connections, namely the row connections and the column connections are conducting portions of a common rod, and are separated by a portion of insulating material. Through connection between a row and a column is established by longitudinal movement of the rod to connect the power input side of the column to the antenna output side of the row. At the same time, both the remaining sections of the row and column are grounded to eliminate the presence of residual stubs from the exchange. Establishment of the required through connection is brought about by means of solenoid activation of rod control means working in association with specially designed cams, the movement of which is effected by the aforementioned drive means.

BRIEF DESCRIPTION OF THE DRAWING

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

FIG. 1 is a perspective view of a matrix cross-point in an unoperated or nontransfer position;

FIG. 2 is a perspective view of the matrix cross-point of FIG. 1 in the operated or transfer position;

FIGS. 3A to 3D as plan views of the operating sequence of a control arrangement to automatically move cross-point rods to obtain a transfer of the power of any one transmitter from one antenna to another antenna; and

FIG. 4 is a perspective view of the cams used and shown in association with the control arrangement of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Where possible throughout all the drawings the same reference numerals have been used to identify the same components.

With reference to FIG. 1, a portion of a single row and column of the matrix of transmission lines aligned in an orthogonal array is shown in its unoperated or nontransfer position. The transmission lines are in the form of coaxial-type conductors of which the outer conductor of each is shown as the rectangular housing 1. The particular geometry of the inner conductors comprising sections 2 of transmission line il-

lustrated was chosen to obtain a good switching arrangement and yet retain the constant impedance required for the line. Each of these sections 2 inner conductors is linked one to the other along each row and column by conducting contacts of portion 3 and 4 which are rigidly secured to or a part of rod 5. The conducting portions 3 and 4 and 12, which together with the insulating portions 14 and 14' comprise rod 5 are formed in a segmented fashion to provide adequate spring contact pressure at each of the four coaxial-type line inner conductor sections 2 as shown at contact points 6, 7, 8 and 9.

With the matrix arranged as illustrated in FIG. 1, each transmission line is electrically continuous via the conducting portions of rod 5 throughout its entire length, that is from the transmitter input end (input line) 10 of each column to the antenna output end (output line) 11 of each row.

Reference is now made to FIG. 2 in which the matrix cross-point illustrated is in the operated or interconnected condition. In order to establish continuity between input 10 and output 11 rod 5 has been moved longitudinally in a forward direction (i.e., to the right in the drawing). This movement has broken the pairs of contacts 8 and 9, 6 and 7, thus isolating the remainder of the column line from input 10 and the remainder of the output row from output 11. Upon completion of travel of actuator rod 13 coupled to rod 5, conducting portion 4 only has contact with an inner conductor section 2 at point 9 and insulating portion 14' now separates points 8 and 9. Conducting portion 3 connects points 7 and 8, and the third conducting portion 12 now engages point 6, points 6 and 7 being separated by insulating portion 14. RF power will now be transferred from input 10 through contacts 7 and 8 via conducting portion 3 to output 11.

In order to avoid stub effects within the operated row-column pair, (for example, the possibility of quarter-wavelength attenuation occurring at the RF frequency employed) the now electrically isolated and unused transmission line sections 2 are grounded. The balance of the antenna or row line is grounded via contact point 9 through conducting portion 4 to the schematically illustrated grounding point 15 which is engaged when pushrod 13 is fully depressed. In a similar manner the remainder of the transmitter or column line is grounded via contact point 6, conducting portion 12 and grounding point 16. It can be seen that point 15 makes no contact at all in FIG. 1 and that point 16 is in contact with insulating portion 14 of FIG. 1.

As mentioned earlier in this specification, any cross-point may be operated remotely in order to choose any transmitter-antenna combination and this may be achieved by a preferred method, hereinafter described, which uses only one motor per column or row (whichever has the least number of lines) of the matrix. Prior art exchanges have required one motor per matrix cross-point. For example, a 10 by 10 exchange would need 100 motors in order to operate each cross-point, whereas in this invention only 10 motors are required, thus greatly simplifying the exchange complexities with resultant economy in manufacture.

Through connection at a required cross-point is achieved by means of a cam assembly which is located between rods 5 and 13 as identified by the circle B in FIGS. 1 and 2. FIG. 3A to 3D show four stages in the operation of the cam assembly in performing through connection of a cross-point while at the same time disconnecting an operating cross-point in the same column. FIG. 3A is the initial and steady state condition while FIG. 3D is the same condition after completion of the switching operation. Two distinct phases should be kept in mind, namely, the connection of one cross-point and the prior disconnection of another.

Referring now to FIGS. 3A to 3D, one drive-cam mechanism is depicted operating on only two possible cross-points of the matrix for the sake of simplicity, however, the reader is reminded that the cam assembly may be extended to accommodate any number of cross-points, typically up to 20. Of the two cross-points shown, the upper one is initially connected, since as described above, the upper pushrod 13 is fully

inserted while the lower pushrod 20 is correspondingly in the nonselected state. The pushrod 13 is provided with a pair of rollers 21, which are axially connected through slot 22 and held in the position shown by spring means (not shown) within pushrod 13. This slot is more clearly shown in pushrod 20 at 23. It limits the travel of the rollers relative to the pushrods.

With the through connection made as shown in FIG. 3A, a selection switch on a remote control panel is set for a desired new through connection. No action takes place, however, until the "Operate Button" is pressed (only momentarily) when motor 17 is activated and rotates in anticlockwise fashion. Since the cam assembly 18 is constrained to vertical motion (in the drawing) only, it is drawn upwards by motor connecting rod 19. It should be noted that the cam assembly in its stationary state is at the nodal position of travel. As the cam assembly 18 and, hence, cam 24 moves upwards, rollers 21 follow the outer (or left-hand) side of the cam face 25 and after a half revolution of motor 17 have moved to the position 26 (see FIG. 3B). In this position pushrod 13 has been withdrawn and, therefore, disconnects the electrical through connection of that matrix cross-point. At the same time, cam 27 has moved into position under rollers 28 of pushrod 20 as shown in FIG. 3B.

At this stage solenoid 29, associated with the preselected cross-point, is energized and forces core 30 to the right as shown in FIG. 3B. Core 30 is connected through the hollowed center of pushrod 20 to the axle of rollers 28. Movement of core 30 thus carries roller 28 through cam keyway 31 to be relocated inside the opposite face of cam 27. This movement is against the action of the return spring on the rollers. The movement of cams 24 and 27 and their associated rollers is permitted by provision of suitable keyways in the cams, as is now more fully explained by referring to FIG. 4.

FIG. 4 is a perspective drawing of the individual cam used in the switching arrangement under remote control. The cams have a ramp or slanted portion 35 with a slot 36 in it connecting two keyways 32 and 34. Rollers 28, which were in contact with the inner cam face may pass through keyway 32 when alignment is reached under the action of the return spring and move along the outsides 33 of the ramp 35 as cam 27 moves upwards. Upon reaching keyway 34, rollers 28 may pass through it provided their associated solenoid is energized to overcome the effect of the internal spring. Movement of the cam in the reverse direction results in rollers 28 engaging the under surface of area 33 on ramp 35. Rollers 28 then proceed to keyway 32 and, assuming the solenoid is no longer energized, pass through keyway 32 under the influence of the return spring to return rollers 28 to their original position.

The description of the changing of through connection will now be continued. The situation shown in FIG. 3B has been reached.

As motor 17 continues to rotate, cam assembly 18 starts to move downward causing rollers 28 to follow the inner face of cam 27 and, therefore, urge pushrod 20 longitudinally in to the right. This then operates the connections as described with reference to FIGS. 1 and 2. This action is illustrated in FIG. 3C which shows motor 17 having made 270° rotation from its position in FIG. 3A. During this stage in FIG. 3C, solenoid 29 is deenergized by, for example, the operation of special switch-cam action provided on the drive motor pulley, though any known means may be employed. During this operation, rollers 21 leave surface 25 of cam 24 and no longer act on pushrod 13, but leave it in the unoperated state.

Upon completion of the full cycle as shown in FIG. 3D, rollers 28 become aligned with keyway 32 and, under the action of the return spring, pass through it to be located on its front surface as were rollers 21 in FIG. 3A. Simultaneously, motor 17, being governed by limit switches, stops. The exchange sequence is now finished with the lower cross-point fully engaged and the upper cross-point fully disengaged.

It will be appreciated that during the switching process the RF power should be removed from the transmitter being switched in order to prevent dangers associated with sudden

removal of the load from the transmitter output and to avoid arcing occurring in the matrix switch points. A convenient way of doing this is to remove the high voltage supply from the output stage of the transmitter. This can be effected automatically when a switching operation is to be performed if pressure contacts switches or relays are located at each matrix cross-point in a position where they are acted on by the end of the cross-point connecting rod when the rod (rod 5 in FIG. 2) is fully in. The end of conducting portions 4 engages the pressure relay to close the RF power supply circuit. As soon as the rod is moved outwards and before it has travelled far enough for a contact to be made or broken elsewhere, the pressure is released from the switch or relay, which acts to disconnect the high voltage power supply. Thus, the RF power is removed from the input prior to establishment of the transfer process and is restored to the exchange only after completion of the switching operation.

In the event of failure of the remote control system, manual operation of any cross-point must be obtainable by use of, say, handle 37 on the end of pushrod 13. It should be clear that manual operation may be carried out, the only criterion being correct positioning of the roller keyways to allow free movement of the pushrod. This is achieved by cranking the motor shaft to bring the keyway into alignment. The cross-point will be operable in either of the positions shown in FIGS. 3A or FIG. 3D, but preferably in the position shown in FIG. 3A.

The foregoing has been a description of an antenna switching exchange associated with a transmitter system wherein m transmitters are coupled to m input lines and n antennas are coupled to n output lines. However, it should be noted that the antenna switching exchange is equally suitable for association with a receiver system wherein m antennas are coupled to the m input lines and n receivers are coupled to the n output lines. Thus, while I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example.

I claim:

1. An antenna switching exchange comprising:
 - an orthogonal array of m input coaxial lines and n output coaxial lines having $m \times n$ cross-points between said input and output lines, where m and n are integers greater than one;
 - each of said m input lines including an inner conductor having n separated sections, each of said n sections being disposed between different adjacent ones of said cross-points;
 - each of said n output lines including an inner conductor having m separated sections, each of said m sections being disposed between different adjacent ones of said cross-points; $m \times n$ longitudinally movable rods each associated with a different one of said cross-points;
 - each of said rods including at least a first and a second conducting portion separated by a first insulating portion;
 - each of said first conducting portions electrically connecting different adjacent ones of said n sections and each of said second conducting portions electrically connecting different adjacent ones of said m sections when said rod is moved to prevent a through connection for its associated one of said cross-points;
 - each of said second conducting portions disconnecting different adjacent ones of said m sections, each of said first conducting portions disconnecting a different adjacent ones of said n sections and each of said second conducting portions connecting one of said adjacent ones of said m sections to one of said adjacent ones of said n sections when said rod is moved to establish a through connection for said associated one of said cross-points;
 - an arrangement coupled to each of said rods for longitudinal movement thereof;
 - a first grounded contact; and
 - a second grounded contact; and
 - wherein

each of said rods further includes a third conducting portion separated from said first conducting portion by a second insulating portion;

movement of each of said rods to establish a through connection for said associated one of said cross-point establishes an electrical connection between said second conducting portion and said first grounded contact and an electrical connection between said third conducting portion and said second grounded contact to ground the unused ones of said m and n sections.

2. An antenna switching exchange comprising:

an orthogonal array of m input coaxial lines and n output coaxial lines having $m \times n$ cross-points between said input and output lines, where m and n integers greater than one;

each of said m input lines including an inner conductor having n separated sections, each of said n sections being disposed between different adjacent ones of said cross-points;

each of said n output lines including an inner conductor having m separated sections, each of said m sections being disposed between different adjacent ones of said cross-points;

$m \times n$ longitudinally movable rods each associated with a different one of said cross-points;

each of said rods including at least a first and a second conducting portion separated by a first insulating portion;

each of said first conducting portions electrically connecting different adjacent ones of said n sections and each of said second conducting portions electrically connecting different adjacent ones of said m sections when said rod is moved to prevent a through connection for its associated one of said cross-points;

each of said second conducting portions disconnecting different adjacent ones of said m sections, each of said first conducting portions disconnecting a different adjacent ones of said n sections and each of said second conducting portions connecting one of said adjacent ones of said m sections to one of said adjacent ones of said n sections when said rod is moved to establish a through connection for said associated one of said cross-points;

an arrangement coupled to each of said rods for longitudinal movement thereof;

said arrangement including

$m \times n$ handles each coupled to an end of a different one of said rods to enable manual movement of said rods;

a first grounded contact; and

a second grounded contact; and

wherein

each of said rods further includes a third conducting portion separated from said first conducting portion by a second insulating portion;

movement of each of said rods to establish a through connection for said associated one of said cross-point establishes an electrical connection between said second conducting portion and said first grounded contact and an electrical connection between said third conducting portion and said second grounded contact to ground the unused ones of said m and n sections.

3. An antenna switching exchange comprising:

an orthogonal array of m input coaxial lines and n output coaxial lines having $m \times n$ cross-points between said input and output lines, where m and n are integers greater than one;

each of said m input lines including an inner conductor having n separated sections, each of said n sections being disposed between different adjacent ones of said cross-points;

each of said n output lines including an inner conductor having m separated sections, each of said m sections being disposed between different adjacent ones of said cross-points;

$m \times n$ longitudinally movable rods each associated with a different one of said cross-points;

each of said rods including at least a first and a second conducting portion separated by a first insulating portion;
 each of said first conducting portions electrically connecting different adjacent ones of said n sections and each of said second conducting portions electrically connecting different adjacent ones of said m sections when said rod is moved to prevent a through connection for its associated one of said cross-points;
 each of said second conducting portions disconnecting different adjacent ones of said m sections, each of said first conducting portions disconnecting a different adjacent ones of said n sections and each of said second portions connecting one of said adjacent ones of said m sections to one of said adjacent ones of said n sections when said rod is moved to establish a through connection for said associated one of said cross-points; and
 an arrangement coupled to each of said rods for longitudinal movement thereof;
 said arrangement including
 a pair of rollers longitudinally movable connected to each of said rods,
 a cam for each of said rods engaging said roller having a first segment slanted with respect to the longitudinal axis of the associated one of said rods including a longitudinal slot therein and second and third segments one at each end of said slanted segment perpendicular to the longitudinal axis of the associated one of said rods, each of said second and third segments having a slot therein transverse of the longitudinal axis of the associated one of said rods permitting said rollers to pass therethrough,
 a solenoid associated with each of said pair of rollers to cooperate in the passage of said rollers through said transverse slot of one of said second and third segments to enable the associated one of said rods to be moved to provide a through connection for the associated one of said cross-points, and
 first means to move each of said cams perpendicular to the longitudinal axis of said rods to longitudinally move said rods in both directions.
 4. An exchange according to claim 3, further including a first grounded contact; and
 a second grounded contact; and
 wherein
 each of said rods further includes a third conducting portion separated from said first conducting portion by a second insulating portion;

movement of each of said rods to establish a through connection for said associated one of said cross-point establishes an electrical connection between said second conducting portion and said first grounded contact and an electrical connection between said third conducting portion and said second grounded contact to ground the unused ones of said m and n sections.
 5. An exchange according to claim 3, wherein
 said first means includes
 m second means each supporting n of said cams associated with n of said rods associated with a different one of said m input lines, and
 a drive means coupled to each of said second means.
 6. An exchange according to claim 5, further including a first grounded contact; and
 a second grounded contact; and
 wherein
 each of said rods further includes a third conducting portion separated from said first conducting portion by a second insulating portion;
 movement of each of said rods to establish a through connection for said associated one of said cross-point establishes an electrical connection between said second conducting portion and said first grounded contact and an electrical connection between said third conducting portion and said second grounded contact to ground the unused ones of said m and n sections.
 7. An exchange according to claim 3, wherein
 said first means includes
 n second means each supporting m of said cams associated with m of said rods associated with a different one of said n output lines, and
 a drive means coupled to each of said second means.
 8. An exchange according to claim 7, further including a first grounded contact; and
 a second grounded contact; and
 wherein
 each of said rods further includes a third conducting portion separated from said first conducting portion by a second insulating portion;
 movement of each of said rods to establish a through connection for said associated one of said cross-point establishes an electrical connection between said second conducting portion and said first grounded contact and an electrical connection between said third conducting portion and said second grounded contact to ground the unused ones of said m and n sections.