Nov. 23, 1965 B. SCHWARTZ 3,219,953

DIRECT TURN STEP ATTENUATOR

Filed Aug. 30, 1963 3 Sheets-Sheet 1

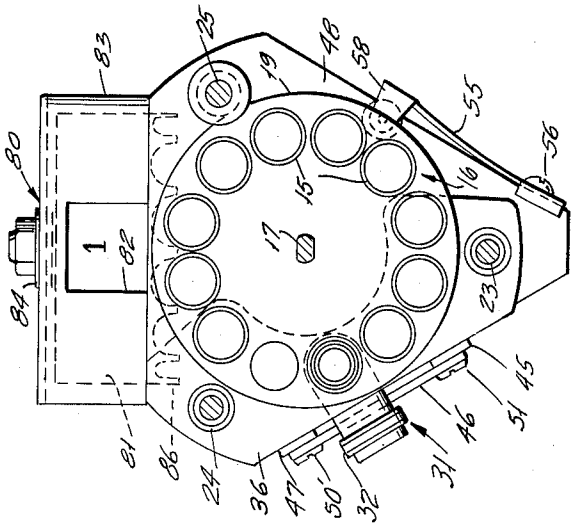


FIG. 3

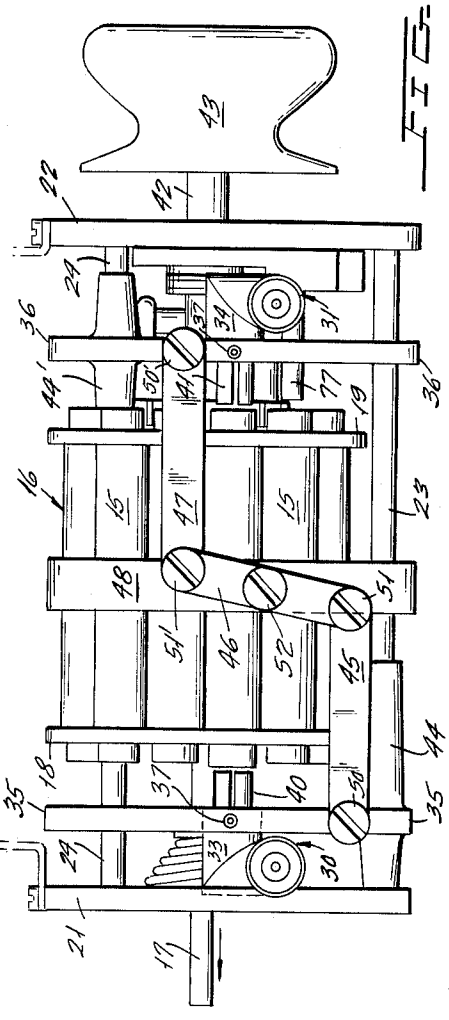


FIG. 2

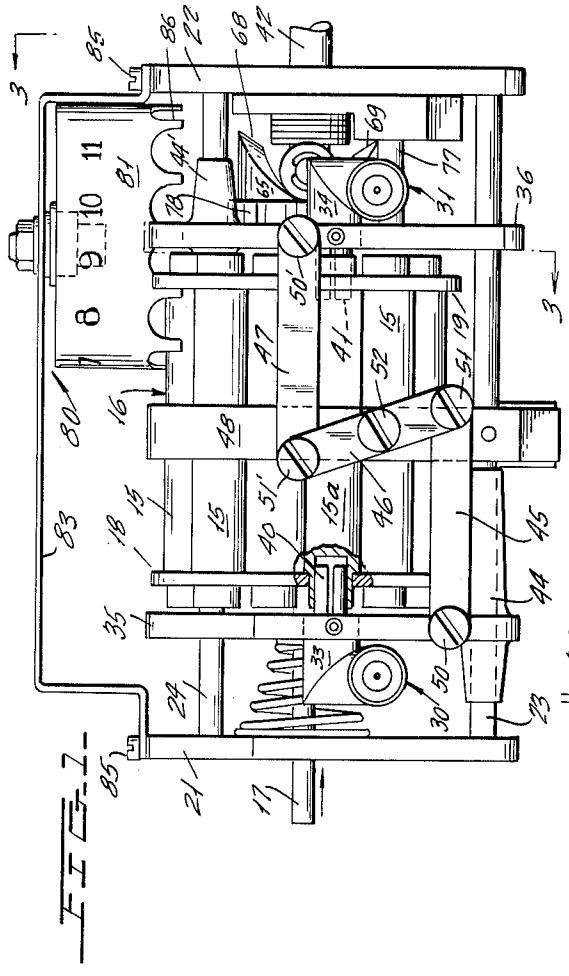


FIG. 1

Nov. 23, 1965 B. SCHWARTZ 3,219,953

DIRECT TURN STEP ATTENUATOR

Filed Aug. 30, 1963 3 Sheets-Sheet 2

FIG. 5.

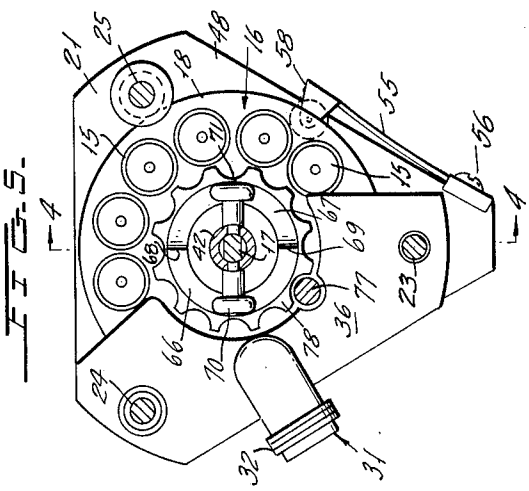


FIG. 7.

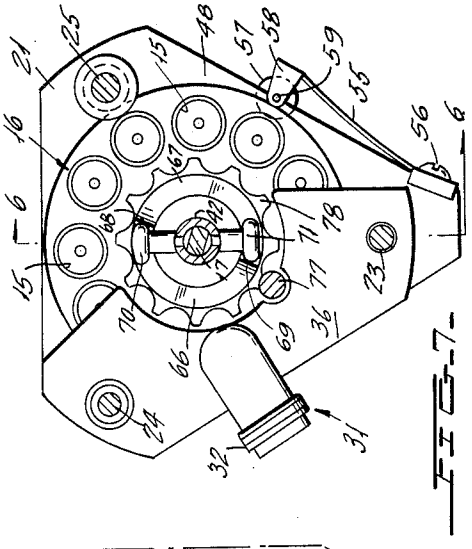


FIG. 4.

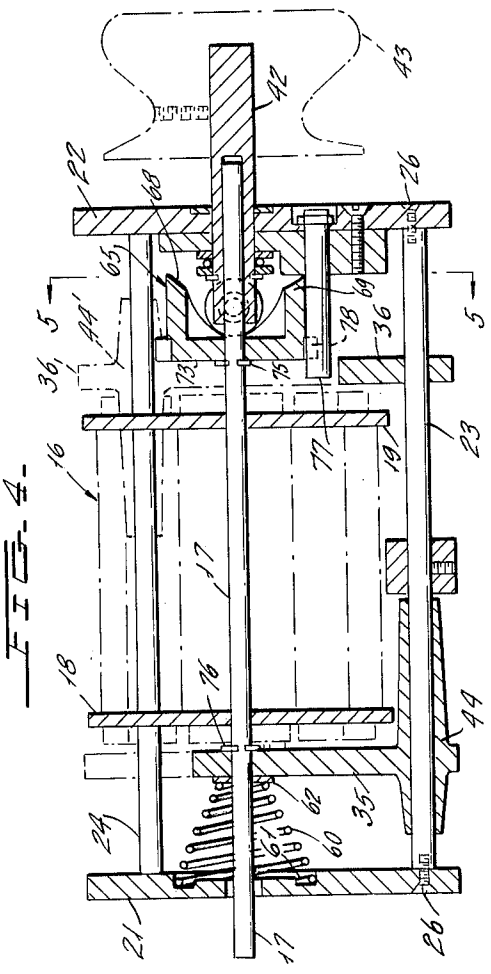
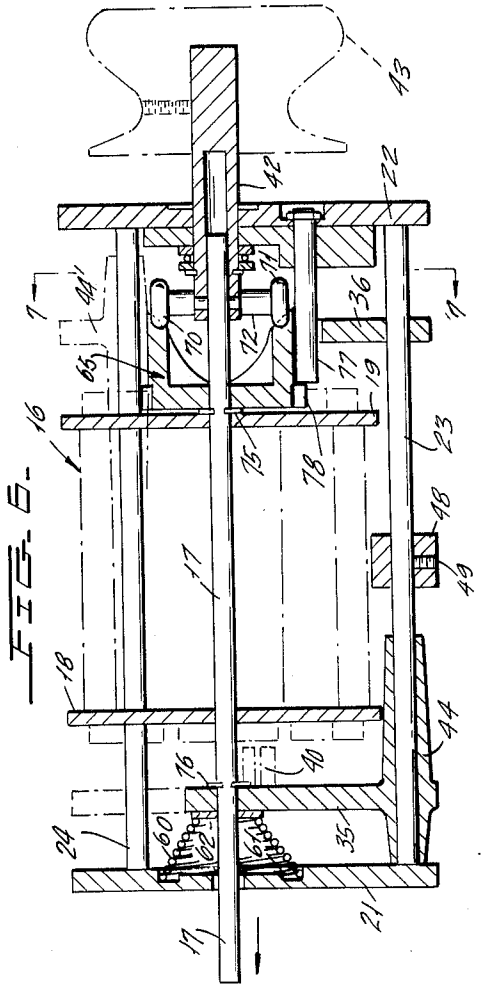


FIG. 6.



Nov. 23, 1965 B. SCHWARTZ 3,219,953

DIRECT TURN STEP ATTENUATOR

Filed Aug. 30, 1963 3 Sheets-Sheet 3

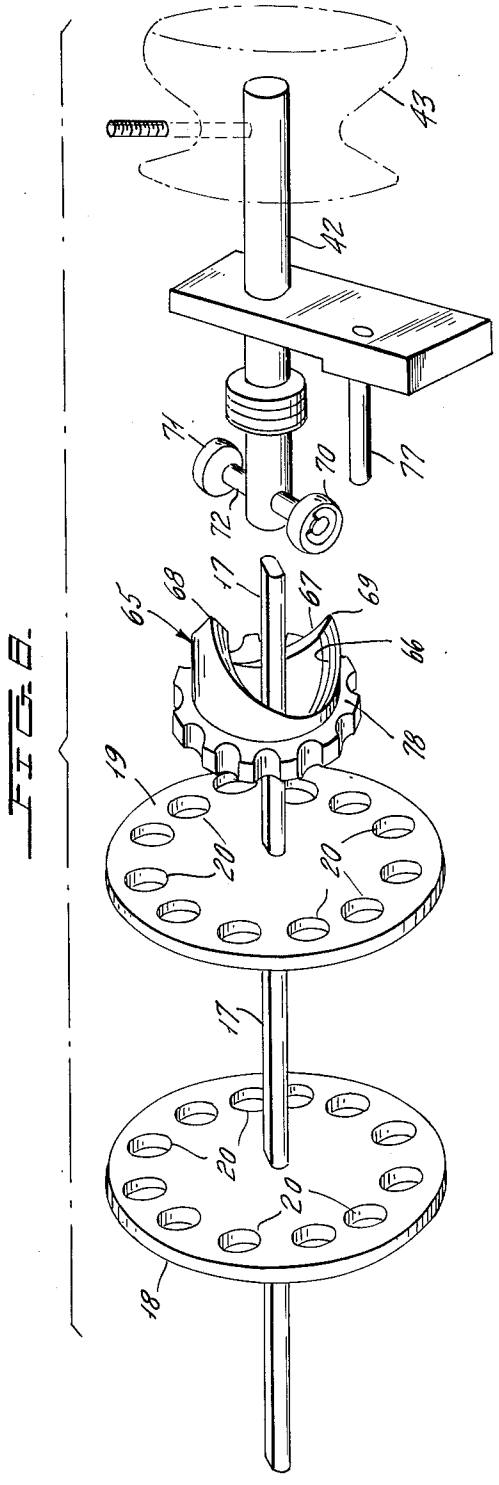


FIG. 8.

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3,219,953

DIRECT TURN STEP ATTENUATOR

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Filed Aug. 30, 1963, Ser. No. 305,447
31 Claims. (Cl. 333—81)

This invention relates generally to microwave step devices such as step attenuators, and more particularly relates to novel direct turn step devices.

In the microwave field attenuators are used that are individually shielded and generally in cylindrical form, with a central conductor. The outer metallic or shielded tubular portion of the attenuator unit or pad is generally grounded, and constitutes the return terminal thereof. Such microwave attenuator units are constructed to attenuate uniformly over a wide frequency band, by predetermined amounts. Individual cylindrical attenuator units are built for attenuating in steps of 5 db, 10 db, 20 db, etc. The attenuators units are inserted in a microwave circuit with firm electrical connection at either end.

The step device provides for the ready selection of any one of a number of coaxial microwave units arranged for individual selection and circuital engagement. As a step attenuator it provides means for the ready selection and circuit engagement of any one of a plurality of attenuator pads contained therein. The cylindrical attenuator pads are arranged in a circular array, and held stationary longitudinally within the step device. The attenuator pad array is rotatable through a protruding front control shaft. Terminal connectors, for coaxial cables of the external microwave circuit, have nipples that are engageable with the selected attenuator pad. Novel mechanical arrangements are provided herein to readily engage and disengage these nipples with an attenuator pad that is selected by rotation of the control shaft.

Prior step devices for microwave components are operated on the pull-turn-push principle. Their control knob or shaft is first pulled away from the device to effect disengagement of the selected component from the terminal connectors. The shaft is thereupon rotated or turned until the next component desired for electrical engagement is thus positioned. Pushing back the control knob completes the selection and connection cycle. Such step device is exemplified by the U.S. patent to M. T. Harges and J. Lorch, Number 2,848,693, for "Step Attenuators," that issued on August 19, 1958, and is assigned to the assignee of this invention.

The present invention is particularly directed to eliminate the pull and push steps at the control knob of microwave step devices, to permit direct turn circuit selection of contained components, in either direction. In accordance with this invention novel camming means is incorporated between the control shaft and the connector mechanism to automatically effect disengagement and reengagement with the microwave components. A balanced camming member effects axial displacement of two spaced plates that mount the terminal connectors. Such displacement is performed against a spring bias that resets the plates and connector engagement in operation.

The direct turn step attenuator of this invention is rugged in construction, and maintains accuracy of alignment and full electrical engagement under adverse ambient environments. The attenuator or other component step desired is readily and directly positioned in the microwave circuit with which the step device is connected. A novel inexpensive index or scale is provided that presents the value or number of the component step engaged.

The above and further features, advantages and objects of the present invention will become more apparent

from the following description of an exemplary embodiment, illustrated in the drawings, in which:

FIG. 1 is a side elevational view of the exemplary step attenuator, in engaged phase, partially broken away.

FIG. 2 corresponds to FIG. 1, during the selection phase, wtih the terminals disconnected from the attenuator pads.

FIG. 3 is the transverse view through the step attenuator, taken along the line 3—3 in FIG. 1, and seen in the direction of the arrows.

FIG. 4 is a longitudinal cross-sectional view through the step attenuator, in the engaged phase per FIG. 1, as indicated by line 4—4 in FIG. 5, partly in phantom.

FIG. 5 is the transverse view through the step attenuator taken along the line 5—5 in FIG. 4, illustrating the camming mechanism thereof, in its selected phase.

FIG. 6 is a longitudinal cross-sectional view corresponding to FIG. 4, but in the selection-disconnect phase of FIG. 2, and as indicated by line 6—6 in FIG. 7.

FIG. 7 is the transverse view taken along the line 7—7 of FIG. 6, illustrating the camming mechanism in its selection phase.

FIG. 8 is a perspective view of the camming mechanism, in exploded view.

The exemplary step attenuator comprises a plurality of attenuator units or pads 15 of different db attenuation values. The pads 15 are arranged equidistantly, in a circular carriage array 16, as seen in FIGS. 1–3. The cylindrical attenuator pads 15 are arranged coaxially about central shaft 17. The attenuator units 15 are supported as an attenuator assembly or carriage 16 by end discs 18, 19. End members 18, 19 each contain a ring of apertures 20 into which the pad end shoulders, of reduced diameter, are mounted, see FIG. 8. The attenuator pads 15 and the end members 18, 19 are assembled as an integral carriage 16 constituting a rotatable attenuator assembly. The control shaft 17 passes through the axis of attenuator assembly 16.

The step attenuator comprises stationary end plates 21, 22 interconnected by spaced longitudinal rods 23, 24, 25. Rods 23, 24, 25 are of equal length, and threaded at their respective ends to receive machine screws 26 for fastening with end plates 21, 22, see FIG. 4. The outer envelope of the step attenuator is fixed, determined essentially by end plates 21, 22 held parallel and in fixed spaced relationship by rods 23, 24, 25.

The step attenuator contains two connector terminals 30, 31. Each of the connectors 30, 31 have a threaded collar 32 for engagement with the threaded bushing of a connector (not shown) at the ends of the connecting flexible external coaxial cables. The central connections of these cable connectors engage the sockets of connectors 30, 31 respectively, in the usual manner. Connectors 30, 31 are 90° in shape with extensions 33, 34 set within corresponding recesses in movable connector plates 35, 36, as seen in FIG. 1. Set screws 37, 37 insure firm engagement of connectors 30, 31 with their respective connector plates 35, 36.

Axial displacement of plates 35, 36 carry the respective connector terminals 30, 31 in the axial direction. However, the aforesaid firm engagement of the respective flexible coaxial cables (not shown) with connectors 30, 31 in no way interferes electrically or mechanically with the high frequency microwave circuit into which the step attenuator of the invention is included with such coaxial cables. Each terminal member 30, 31 has axially and inwardly projecting connector sections 40 and 41 respectively.

The connector sections 40, 41 comprise outer resilient slotted conductors for engagement with the end terminals of the attenuator pads 15. The projecting connector

sections 40, 41 are in axial alignment, across the step attenuator, in order to be engaged selectively with the longitudinal ends of individual selected attenuator pads. The outer slotted conductors 40, 41 are at ground potential with respect to the outer conductors of their respective connectors 30, 31 and with ground of the step attenuator assembly. Connector portions 40, 41 make firm mechanical and electrical connection with the outer cylindrical conductors of the pad 15 to which they are connected. At the interior of the respective extensions 40, 41 are central connecting pins (not shown) for engaging with the corresponding central connecting conductors of the attenuator pads, as will be understood by those skilled in the art.

Longitudinal displacement of terminal connectors 30, 31 inwardly, effects engagement of the respective projecting terminals 40, 41 with a selected attenuator unit 15. The central connections of the selected attenuator unit 15 thereupon become electrically interconnected with the central sockets of connectors 30, 31 respectively, and in circuit with the coaxial cables to the step attenuator. FIG. 1 shows the step attenuator in such electrically engaged position, with the movable connector plates 35 and 36 in their innermost position, with connector portions 40, 41 in engagement with the selected attenuator pad 15*a*.

The movable connector plates 35 and 36 are operated in unison, but in opposite directions, as set forth in the aforesaid patent. The attenuator pad assembly 16 is held in fixed axial position in the step attenuator. Rotational displacement of the carriage 16, through the control shaft 17, positions a desired attenuator pad in the engaging position 15*a* shown in FIG. 1. Such rotational displacement of pad assembly 16 can occur only when connectors 30, 31 are disengaged from the assembly 16. This corresponds to the "pull" position of control shaft in the patent embodiment.

Axial shaft 17 is rotatably mounted, and is also longitudinally displaceable. Shaft 17 has a generally rectangular cross-section, basically with two parallel flats. The carriage 16 plates 18, 19 have central openings shaped to shaft 17; and are thus turned thereby. Shaft 17 extends beyond end plate 21 without engaging it. Its inner end is rotatably housed in the hollow of tube 42 and is suitably journaled in end plate 22. Control knob 43 is secured to the outer end of tube 42.

Displaceable connector plates 35, 36 each have an integral extended bearing 44, 44′ about respective tie rods 23, 24. The interiors of bearings 44, 44′ desirably have a bearing sleeve such as of "Oilite." Plates 35, 36 are thus maintained in parallel alignment for accurate electrical engagement and disengagement action of their associated terminals 40, 41. Further, they are readily movable along the tie rods 23, 24, with negligable friction or skewing. The connector plates 35, 36 are thus readily operable mechanically, in the manner to be set forth, in their electrical connection function.

In the exemplary step device, controlled displacement of connector plate 35, is transmitted, in suitable reversed orientation to the opposite or remote connector plate 36. Towards this end linkage arms 45, 46, 47 are utilized. Central linkage arm 46 is pivotally mounted on a cross member 48. Cross member 48 is secured to rods 23, 24 by set-screws 49. One end of arm 45 is pivotally secured to the top surface of movable connector plate 35 by a suitably constructed screw member 50. Screw member 50 has a collar engagable with arm 45 and screw threads secured with connector plate 35. In a similar manner, the far end of arm 47 is pivotally secured to connector plate 36 by screw member 50′. The linkage arm 45 is pivotally linked with one end of central pivotal arm 46 by screw member 51. Reference is made to FIG. 7 of the aforesaid patent for details as to such linkage connections.

Arm 46 is free to pivot with respect to arm 45, with screw member 51 as the pivotal point. The head of screw member 51 overlies the top surface of pivotal arm 46, to secure the pivotal connection between arms 45 and 46. The ends of linkage arms 46 and 47 are pivotally connected by screw member 51′. Finally, the central portion of pivot arm 46 is pivotally mounted by screw member 52 on the cross member 48. The lower threaded portion of screw member 52 is engaged with a coacting threaded portion in cross member 48.

The action of the pivoted linkage 45, 46, 47, is to cause connector plate 36 to move in a complementary manner with connector plate 35 when actuated by control shaft 17. When control plate 35 is moved to the right, for the engage or "push" position of FIG. 1, in order for its connector portion 40 to engage attenuator pad 15*a*, the companion remote connector plate 36 is motivated in the opposite direction, to the left, in order to establish connection between its connector portion 41 and the selected attenuator pad 15*a*. This is accomplished by the action of the linkage 45, 46, 47 between the plates 35 and 36.

When the control shaft 17 is moved to the left, for the disengage or "pull" position shown in FIG. 2, the connector plate 35 is moved to the left to disengage its connector section 40 from positioned attenuator pad 15*a*. The linkage 45, 46, 47 simultaneously motivates the remote connector plate 36 to the right, to disengage its connector portion 41 from attenuator pad 15*a*. Such disengagement of the connectors 30, 31 from the attenuator assembly, permits the "turn" action on the attenuator assembly 16 for further selection through control shaft 17. The pivotal screw members 50, 51, 52 maintain the linkage assembly in proper pivotal relation for the inverse actuation of connector plates 35, 36.

The engagement of control shaft 17 with the pad assembly 16 is through the flattened openings centrally of the end members 18, 19 of the assembly 16 (see FIG. 8). Thus rotation of flattened control shaft 17 carries with it the attenuator pad assembly 16, through the confining coacting openings in respective members 18 and 19. Also, such engagement permits shaft 17 to move axially for its "push" and "pull" actuations of connector plates 35 and 36, without axially displacing the attenuator pad assembly 16. The coaction of the openings of members 18 and 19 constitute central supports for the assembly 16. The central pad assembly 16 is desirably held against axial displacement by suitable means, such as a grooved post or collar as shown at 61, 62 in FIG. 4 of the patent referred to.

Extending at the side of the step attenuator is a spring arm 55 which serves as a detent to retain the pad assembly 16 in its preset angular positions. Spring arm 55 is mounted from cross member 48 through machine screw 56. A roller 57 is supported in ears 58 depending from arm 55 by means of a pin 59. The roller 57 is proportioned to fit between adjacent attenuator pads 15, as seen in FIG. 3. Roller 57 is tangent between adjacent attenuator pads 15, and serves to arrest unintended rotational displacement through spring pressure of spring arm 55 transmitted to roller 57. Accordingly when the control shaft 17 rotates the attenuator pad assembly 16, it is maintained in the desired angular positions selected for electrical engagement with connectors 30, 31.

A conical spring 60 is seated in a recess 61 in end plate 21, about central control shaft 17. The spring apex region is pressed against a washer 62 at the side of connector plate 35. Plate 35 is thereby spring biased to the right, into "normally engaged" position, see FIGS. 1 and 4. Connector terminal 40 is held pressed into contact with the positioned pad 15*a*. Through linkage 45, 46, 47 plate 36 and its connector terminal 41 is also held thereby in "normally engaged" position; completing a series electrical circuit with selected attenuator pad 15*a*, between terminals 30, 31.

An important feature of the present invention is the novel means and mechanism for automatically disengaging (the "pull") and reengaging (the "push") the terminal

connections 40, 41 with the selected pad 15*a* (or other type of electrical component) of the step device. With such mechanism, direct turn in either direction for pad selection changes is rendered feasible and practical, as will now be described:

A three-dimensional cam 65, in outer cylindrical form is mounted on control shaft 17. FIG. 8 best illustrates cam 65, with its two symmetrical cam faces 66, 67. Faces 66 and 67 extend for 180° each, and intersect at two apices 68, 69. A set of opposed cam rollers 70, 71 are mounted from control tube 42 on a transverse rod 72. The normal engagement position of rollers 70, 71 with cam 65 is at the valleys of the arcuate cam surfaces 66, 67, as seen in FIGS. 1, 4 and 5. This corresponds to the static position of the mechanism, and the "normally engaged" one for the step attenuator.

A C- or E-clamp 75 is seated into slits in control shaft 17 adjacent the back side 73 of cam 65, when in its reposed or static phase, per FIG. 4. A similar clamp 76 is fastened on shaft 17 adjacent the inner side of connector plate 35 when in its "connected" position, per FIG. 4. At this juncture it is realized that should cam 65 be pressed to the left, it would carry shaft 17 therewith due to clamp 75. Shaft 17, being readily longitudinally displaceable, would thereupon motivate connector plate 35 due to clamp 76. Plate 35 would compress conical spring 60, as shown in FIG. 4.

Further, the displacement of plate 35 would conversely motivate companion plate 36 through the connecting linkage. The spreading apart of connector plates 35, 36 in this manner, in turn fully disconnects both terminal portions 40 and 41 from the previously selected pad at position 15*a*, as shown in FIGS. 2 and 6. Such condition or phase of the step attenuator would permit direct rotation of control shaft 17 to turn carriage 16 to a new angular position, to reselect an electrical component thereof for the microwave circuit position 15*a*.

The camming mechanism hereof, operated on a direct turn basis, provides the aforesaid operations and functions. Control tube 42 is rotated through attached knob 43. Extending cam rollers 70, 71 thereupon ride up associated cam surfaces 66, 67. Tube 42, and hence rollers 66, 67 are held against axial displacement. This causes cam 65 per se to be moved, to the left in FIG. 6. An elongated pin 77 extends from stationary end plate 22. Pin 77 normally engages with one of the semi-circular notches of a scalloped ring 78 at the base of cam 65.

Cam 65 is constrained solely to axial movement due to forces on its arcuate surfaces 66, 67 from rollers 70, 71, while its ring 78 is engaged with pin 77. The notches in ring 78 are angularly oriented to correspond precisely with the normally connected positions of the pads 15 of carriage 16. A corresponding notch is thus engaged with pin 77 for all the selected positions 15*a*. The compound shape of cam surfaces 66, 67 provide force components in both the axial and rotational directions when rollers 70, 71 ride up on them. The rotational component is in the same direction as one turns knob 43. The axial component is inwardly of the structure.

The longitudinal extent of pin 77 is made to hold cam 65 against rotation until the terminal connectors 40, 41 are safely disengaged from the pad (or component) 15*a*. As seen in FIG. 4, a notch of ring 78 is intermeshed with pin 77 when the device is in normal engagement and use, with rollers 70, 71 seated in the cam 65 valleys. As tube 42 and rollers 70, 71 are turned through knob 43, in either direction, cam 65 is moved inwardly of the device, to the left in FIGS. 2 and 6 until the notch of the ring 78 engaging the pin 77 is withdrawn from engagement therewith. Such displacement of cam 65 axially forces shaft 17 inwardly (to the left in FIGS. 4 and 6) because the back side 73 of the cam 65 contacts the seated clamp 75.

Connector plate 35 is in turn moved against spring 60 through clamp 76 on shaft 17, so that the spring 60 will tend to drive the shaft 17 outwardly (to the right in FIGS. 4 and 6) and force the cam 65 outwardly and thus force the cam ring 78 into contact with the pin 77. Concurrently, connector plate 36 is moved to the right, away from carriage 16 through linkage 45, 46, 47. The terminal connectors 40, 41 are thereby disengaged from pad 15*a* when cam 65 is sufficiently displaced inwardly towards end member 19 by rollers 70, 71. When pad assembly 16 is thus in condition to be rotated without damage to the fragile connectors 40, 41, the engaged notch of scalloped cam ring 78 becomes disengaged from pin 77, as shown in FIG. 6. Normally, a considerabe constant torque is applied to the knob 43 and unless such torque is terminated, considerable rotational force component is by this time built up on cam surfaces 66, 67. The cam 65 is thereupon rotated. If only slight torque is applied, the friction between the pin 77 and the flat surface of the ring 78 facing outwardly and confronting the tip of the pin may cause the tip of the pin 77 to rest poised in position on the flat surface of the ring 78 between the notches therein. This is an unusual situation, however, which will occur only if adequate constant torque is not applied to the knob 43, and it is a by-product of the structure of the mechanism shown rather than an object of this invention. During rotation of the cam 65, in either direction, the spring 60 maintains the cam 65 biased to the right. The outer (right) side of the ring 78 continues to press against the tip of the pin 77 during the interval of time required to turn the cam 65 and the ring 78 from one notch to the adjacent notch in the ring 78. When alignment of the next notch with the pin is reached, then the spring 60 will tend to drive the cam 65 outwardly engaging the aligned notch with the pin 77. If the knob 43 is turned very slowly and the pin binds on the flat outer face of ring 78 followed by reversal of torque on knob 43, then the cam ring 78 may be turned back so that the same notch will engage with the pin, but this is an irregular mode of operation which would be employed only if, for example, the operator suddenly changed his mind or were playing with the mechanism. Manifestly, the pin 77 and the cam ring 78 serve to hold the shaft 17, the clamp 76, the end plate 36 and the spring 60 back between engagement of notches in the ring 78 with the pin 77 and full retraction of the cam 65 to its normal outward position, shown in FIG. 4.

Rotation of cam 65 correspondingly turns control shaft 17 due to their rectangular engagement. Similarly, shaft 17 rotates attenuator pad carriage 16 through the engaged end discs 18, 19. The axial extent of the cam 65 preferably prevents its tips 68, 69 from being overridden by rollers 70, 71. In practice, regular turning of knob 43 may be arranged to shift the carriage 16 by several positions before the cam resets and the connectors 40, 41 reengage the pad then at position 15*a*. Slow turning of the knob would simply displace and register the next adjacent pad (or component) 15 in the circuit through the step device. The cooperation of pin 77 and ring 78 provide assurance that the interlinked end plates and connectors 40, 41, will be held apart from pad assembly 16 during rotation of cam 65 from disengagement of one notch in the ring 78 from the pin 77 to engagement of the same or another notch with the pin 77. As seen in FIGS. 4, 6, 7 and 8, the configuration of the notched ring 78 permits coaction with the pin 77 to assure safe disengagement of the connectors 40, 41 from the attenuator pads until subsequent reengagement of the pad and the connector in alignment therewith, and the pin 77 and an aligned notch in ring 78. The pin thereupon permits the cam 65 to slide back into a "home" or static position when the pin and notch are aligned, to permit the cam and shaft 42 to resume their static conditions and the connectors to engage with the selected and positioned pad 15*a*. Normally in order to advance the cam ring 78 one notch with reference to pin 77, it is first necessary to turn the knob 43 through a disengagement angle of about 90°, as from the position shown in FIG. 5 to the position shown in

FIG. 7 in order to drive cam 65 inwardly far enough to disengage a notch in cam ring 78 from the end of pin 77, and then to rotate the knob an additional (net) angle equal to the angle between notches e.g., if there are twelve equally spaced pads, the angular displacement therebetween will be 30° as will be the angles between adjacent ones of the 12 notches shown. Thus, in operation knob 43 would be rotated through a gross angle of say 120° and then it would be returned 90° if manual force were removed from knob 43. Then spring 60 would force the cam 65 outwardly towards the knob 43 and as a result, because the cam would be pinned, the cam faces 66 and 67 would force rollers 70 and 71 back from the positions shown in FIG. 6 towards their original positions about shaft 17 until they reached the valleys between the inclined cam faces as shown in FIG. 4. As cam 65 had been rotated, say 30°, the valleys would have been displaced by a substantially identical angle, so the net angle of rotation of knob 43 would be a substantially identical angle, e.g., about 30°. Considerably less than a 360° gross angular rotation of knob 43 will have been required to advance the central shaft 17 and pads 15 by one pad position, and the net angle would be substantially equal to the angular distance between the pads about shaft 17, e.g., 30°.

If pin 77 were substantially shorter, and connectors 40, 41 were correspondingly shorter or required to travel a correspondingly shorter distance, then the difference between the gross angle and the net angle could be reduced substantially. That difference represents play that is necessary to permit axial displacement of the cam 65 inwardly, and the end plates 35, 36 and connectors 40, 41 outwardly to disengagement position with respect to the assembly.

The switch-over of attenuator pads 15, selectively through knob 43, is readily attained, from either direction of rotation. The turning torque is normally manual as for prior art step devices. The mechanism is safeguarded from internal damage, is foolproof and rugged. The electrical connections are firm and axially precise. The biasing spring 60 insures static stability of operation. Additional springs may be incorporated in the step device hereof. A spring coaxially in the camming mechanism, and/or at the linkage 45, 46, 47 may be used for further firming of forces and action during switchovers, particularly in motorized remotely controlled applications. The control back-lash is negligible with the use of symmetrical cam 65.

Indicator 80 comprises an index cylinder 81 bearing numerals suitably related to the electrical components as pads 15 in the step device. The numerals or indices may identify the db attenuation of the pad then in selected position 15*a* through a suitable escutcheon or window 82. Index cylinder 81 is in cup form, rotatably mounted under bracket 83 through a central bearing 84. Bracket 83 is supported on stationary end plates 21, 22 with screws 85, 85.

The depending rim 86 of cylinder 81 is notched or scalloped and arranged to coact with the tubular pads 15 of cylindrical assembly 16. The scalloped rim 86 meshes with the pads 15. The index cylinder 81 is thereby rotated in direct correspondence with assembly 16. The indices are arranged in phase with their associated pads 15. The numeral or index appearing at window 82 is set to indicate which pad is at the selection-connection-position 15*a*.

It is to be understood that the present invention is generally applicable for step presentation of longitudinal electrical or microwave components other than attenuator pads 15. It is also useful in coaxial switching applications. Further, as indicated manual or motorized, close or remote, utilization of the invention step apparatus and principles are contemplated. The number of switchable components, or the general shape and arrangement of the elements of the step device hereof are of course optional.

While the present invention has been described in connection with a specific embodiment, its novel features and principles may take other forms of application, as will be understood by those skilled in the art, and it is not intended to be limited except as set forth in the following claims.

I claim:

1. A step device of the character described comprising: an assembly of circuit pads longitudinally oriented in a cylindrical array and rotatably mounted in the device, a pair of connector holders mounted across said assembly, a terminal connector carried by each said holder for selective circuital connection with the terminal ends of said pads, said holders being individually displaceable to engage and to disengage said connectors from the pads, spring means arranged to normally bias said connector holders inwardly towards said assembly to maintain said terminal connectors in circuital engagement with the selected pad, mechanism including a control shaft for actuating the mechanism through turning of the shaft, said connector holders being mechanically interrelated with said mechanism to effect displacement of said holders outwardly of said assembly and disengage their respective connectors from said selected pad upon the operation of said mechanism by turning of said shaft, and means mechanically responsive to further turning of said control shaft for shifting the angular position of said assembly in correspondence with the further turning of said shaft for positioning a successive pad for circuital engagement, whereupon said spring means presses said connector holders towards said assembly to effect engagement of said connectors with the successively positioned pad said mechanism including first means rotatably mounted coaxially with said assembly and second means fixed against rotation relative to said device for cooperating to retain said holders spaced apart during shifting of the angular position of said assembly and releasing said holders upon alignment of a pad with said connectors, one of said first and second means being movable longitudinally of said array in correspondence with displacement of said holders.

2. A step device as claimed in claim 1, in which said spring means comprises a compression element.

3. A step device of the character described comprising a frame, an assembly of circuit pads longitudinally oriented in a cylindrical array and rotatably mounted in said frame, a pair of connector holders mounted apart across said assembly, a terminal connector attached to each said holder for selective circuital connection with the terminal ends of said pads, said holders being individually displaceable longitudinally to engage and to disengage said connectors from the pads, spring means arranged to normally bias said connector holders inwardly towards said assembly to maintain said terminal connectors in circuital engagement with the selected pad, camming mechanism and a control shaft extending from said frame and for actuating the camming mechanism through turning of the shaft, said connector holders being mechanically responsive to said camming mechanism to effect displacement of said holders outwardly of said assembly and disengage the respective connectors in unison from said selected pad upon operation of said camming mechanism by said shaft, means for maintaining the said connector disengagement until a successive pad is moved into position for connector reengagement, and means mechanically responsive to further turning of said control shaft for shifting the angular position of said assembly in either direction in correspondence with the further turning of said control shaft for positioning the successive pad for circuital engagement, whereupon said spring means presses said connector holders inwardly towards said assembly to effect engagement of said connectors with the successively positioned pad said cam mechanism including first means rotatably mounted coaxially with said assembly and second means fixed against rotation relative to said device for cooperating to retain said holders spaced apart during shifting of the angular position of said assembly and releasing said holders upon

alignment of a pad with said connectors, one of said first and second means being movable longitudinally of said array in corespondence with displacement of said holders.

4. A step device of the character described comprising a frame with two end members and longitudinal tie-rods holding said end members in spaced relation, an assembly of attenuator pads longitudinally oriented in a cylindrical array parallel to said tie-rods and rotatably mounted in said frame, a pair of connector plates mounted apart across said assembly and parallel to said end members, a terminal connector carried by each said plate for selective circuital connection with the terminal ends of said pads, said plates being individually displaceable longitudinally to engage and to disengage said connectors from the pads, compression spring means pressed against said frame and arranged to normally bias said connector plates inwardly towards said assembly to maintain said terminal connectors in circuital engagement with the selected pad, camming mechanism with a portion thereof supported for longitudinal displacement, a control shaft extending from said frame for actuating said camming mechanism through turning of the shaft, said connector plates being mechanically associated with said camming mechanism to effect displacement of said plates outwardly of said assembly and disengage the respective connectors in unison from said selected pad upon longitudinal displacement of said portion, means cooperating with said portion for maintaining the said connector disengagement until a successive pad is moved into position for connector reengagement, and means mechanically responsive to further turning of said control shaft for shifting the angular position of said assembly by one step in correspondence with the further turning of said control shaft for positioning the successive pad for circuital engagement, whereupon said spring means presses connector plates inwardly towards said assembly to effect engagement of said connectors with the successively positioned pad.

5. A step device as claimed in claim 4, in which said spring means comprises a coiled compression spring pressed between a frame end member and the adjacent connector plate.

6. A step device as claimed in claim 4, in which said connector plates slidably engage at least one of said tie-rods during their longitudinal displacements.

7. A step device as claimed in claim 4, in which said control shaft is rotatably journalled in a frame end member.

8. A step device of the character described comprising an assembly of circuit pads longitudinally oriented in a cylindrical array and rotatably mounted in the device, a pair of connector holders mounted apart across said assembly, a terminal connector carried by each said holder for selective circuital connection with the terminal ends of said pads, said holders being individually displaceable longitudinally to engage and to disengage said connectors from the pads, spring means arranged to normally bias said connector holders inwardly towards said assembly to maintain said terminal connectors in circuital engagement with the selected pad, cam means supported for longitudinal displacement, cam actuator means coactable with said cam means, a control shaft extending from said device and for operating said actuator means against said cam means, said cam means being thereupon moved longitudinally upon turning of said control shaft, said connector holders being mechanically associated with said cam means to effect displacement of the holders outwardly of said assembly and disengage the respective connectors from said selected pad upon the operation of said cam actuator means by said shaft, and means mechanically responsive to further turning of said control shaft for shifting the angular position of said assembly in correspondence with the further turning of said control shaft for positioning a successive pad for circuital engagement, whereupon said spring means presses said connector holders inwardly towards said assembly to effect engagement of said connectors with the successive positioned pad means fixed against axial motion relative to said assembly for cooperating with said cam means to retain said holders spaced apart during shifting of the angular position of said assembly and releasing said holders upon alignment of a pad with said connectors.

9. A step device as claimed in claim 8, in which said two cam faces are each substantially inclined with respect to the longitudinal axis of the pad assembly.

10. A step device as claimed in claim 8, in which said cam means includes a second set of two cam faces in individual coaction with said cam actuator means.

11. A step device as claimed in claim 8, in which said cam means includes a second set of two cam faces in individual coaction with said cam actuator means, said second set of cam faces being arrayed in mirror symmetry to the first cam face set.

12. A step device as claimed in claim 8, in which said two cam faces are each substantially inclined with respect to the longitudinal axis of said pad assembly and said cam means includes a second set of two cam faces in individual coaction with said cam actuator means, said second set of cam faces being arrayed in mirror symmetry to the first said cam face set.

13. A step device of the character described comprising a frame, an assembly of circuit pads longitudinally oriented in a cylindrical array and rotatably mounted in said frame, a pair of connector holders mounted apart across said assembly, a terminal connector attached to each said holder for selective circuital connection with the terminal ends of said pads, said holders being individually displaceable longitudinally to engage and disengage said connectors from the pads, spring means arranged to normally bias said connector holders inwardly towards said assembly to maintain said terminal connectors in circuital engagement with the selected pad, cam means with at least two cam faces supported for longitudinal displacement, cam actuator rollers coactable with said cam faces, a control shaft extending from said device and mounting said rollers for operation against said cam faces, said cam means being thereupon moved longitudinally when actuated by said rollers upon turning of said control shaft, said connector holders being mechanically interrelated with said cam means to effect displacement of the holders outwardly of said assembly and disengage the respective connectors from said selected pad upon the longitudinal movement of said cam means by said rollers, means for maintaining the said connector disengagement until a successive pad is moved into position for connector reengagement, and means mechanically responsive to further turning of said control shaft for shifting the angular position of said assembly in either direction in correspondence with the further turning of said shaft for positioning the successive pad for circuital engagement, whereupon said spring means presses said connector plates inwardly towards said assembly to effect engagement of said connectors with the successively positioned pad.

14. A step device as claimed in claim 13, further including a plurality of studs extending from said control shaft with each of said cam actuator rollers being rotatably mounted on one of said studs for its coaction with an associated cam face.

15. A step device as claimed in claim 13, in which said two cam faces are each substantially inclined with respect to the longitudinal axis of the pad assembly.

16. A step device as claimed in claim 13, in which said cam means includes a second set of two cam faces in individual coaction with said rollers.

17. A step device as claimed in claim 13, in which said two cam faces are each substantially inclined with respect to the longitudinal axis of said pad assembly and said cam means includes a second set of similar cam faces in individual coaction with said rollers.

18. A step device of the character described comprising a frame with two end members and longitudinal tie-

rods holding said end members in spaced relation, an assembly of attenuator pads longitudinally oriented in a cylindrical array and rotatably mounted in said frame, a pair of connector plates mounted apart across said assembly, a terminal connector carried by each said plate for selective circuital connection with the terminal ends of said pads, said plates being individually displaceable in the longitudinal direction to engage and to disengage said connectors from the pads, spring means pressed against said frame and arranged to normally bias said connector plates inwardly towards said assembly to maintain said terminal connectors in circuital engagement with the selected pad, cam means with at least two cam faces arrayed in bi-symmetrical relation and supported for longitudinal displacement, cam actuator rollers coactable with said cam faces, a control shaft extending from said frame and mounting said rollers for operation against said cam faces through turning of the shaft in either direction, said cam means being thereupon moved longitudinally when actuated by said rollers upon the turning of said control shaft, said connector plates being mechanically responsive to displacement of said cam means to effect movement of said plates away from said assembly and disengage their respective connectors in unison from said selected pad upon the longitudinal displacement of said cam means by said rollers, means for maintaining the said connector disengagement until a successive pad is moved into position for connector reengagement, and means mechanically responsive to further turning of said control shaft for shifting the angular position of said assembly in either direction by one step in correspondence with the further turning of said shaft for positioning the successive pad for circuital engagement, whereupon said spring means presses said connector plates inwardly towards said assembly to effect engagement of said connectors with said successively positioned pad.

19. A step device as claimed in claim 18, in which said spring means comprises a coiled compression element pressed between a frame end member and the adjacent connector plate.

20. A step device as claimed in claim 18, in which said connector plates slideably engage at least one of said tie-rods during their longitudinal displacements.

21. A step device as claimed in claim 18, in which said control shaft is rotatably journalled in a frame end member.

22. A step device as claimed in claim 18, further including a plurality of studs extending perpendicularly from said control shaft with each of said cam actuator rollers rotatably being mounted on one of said studs for its coaction with an associated cam face.

23. A step device as claimed in claim 18, in which said two cam faces are each inclined with respect to the longitudinal axis of the pad assembly and said cam means includes a second set of two cam faces similarly inclined as the first set.

24. A step device as claimed in claim 18, in which said cam means includes a second set of two cam faces in individual coaction with said rollers, said second set of cam faces being arrayed in mirror symmetry to the first cam face set.

25. A step device as claimed in claim 18, in which said two cam faces are each inclined with respect to the longitudinal axis of said pad assembly and said cam means includes a second set of two cam faces in individual coaction with said rollers, said second set of cam faces being arrayed in mirror symmetry to the first cam face set.

26. A step device of the character described comprising a pair of plate members spaced apart, a cylindrical assembly of circuit pads, a pair of terminal connectors, individually mounted on said plate members for selective engagement with said pads across the terminal ends thereof, means interlinking said pair of plate members to establish direct engagement and disengagement of said pair of terminal connectors with as elected pad through the displacement of said plate members in opposing directions and control means including a shaft coaxial with said assembly and extending from the device for external actuation and mechanism for translating reciprocation of said shaft in either rotational direction through a disengagement angle required for disengagement of said terminals from a pad plus turn through a further net angle substantially equal to that between successive pads on the assembly into a corresponding change of pad in circuit with said connectors, wherein the turn of said control means through the disengagement angle initially effects the displacement of said plate members in unison to pad disengagement, which with substantial continuity of direct turn actuation thereupon causes the repositioning of said assembly by one step through the shaft turn for operative circuital engagement of said corresponding pad with the connectors, and then effecting subsequent reengagement of said connectors with the newly selected pad.

27. A step device as claimed in claim 26, in which said mechanism contains spring means arranged to normally bias the mechanism into its stable relation and the plate members into full pad engagement position for their associated terminal connectors.

28. A step device of the character described comprising a pair of plate members spaced apart and movable along a longitudinal axis, an assembly of circuit pads longitudinally oriented in a cylindrical array, a pair of terminal connectors individually mounted on said plate members for selective engagement with said pads across the terminal ends thereof, means interlinking said pair of plate members to establish direct engagement and disengagement of said pair of terminal connectors with a selected circuit pad through the displacement of said plate members in opposing directions, and control means including a shaft coaxial with said assembly and extending from the device for external actuation and mechanism for translating reciprocation of said shaft in either rotational direction through a disengagement angle required for disengagement of said terminals from a pad plus turn through a net angle equal to that between successive pads on the assembly into a corresponding change of pad in circuit with said connectors, wherein the turn of said control means through the disengagement angle initially effects the displacement of said plate members in unison to pad disengagement which with subsequent substantial continuity of direct turn actuation through the net angle thereupon causes the turning of said assembly by one step through the shaft turn for operative circuital engagement of said corresponding pad with the connectors, and then effecting subsequent reengagement of said connectors with the newly selected pad.

29. A step attenuator of the character described comprising a pair of plate members spaced apart and movable along a longitudinal axis, an assembly of attenuator pads longitudinally oriented in a cylindrical array, a pair of terminal connectors individually mounted on said plate members for selective engagement with said pads across the terminal ends thereof, means interlinking said pair of plate members to establish direct engagement and disengagement of said pair of terminal connectors with a selected attenuator pad through the displacement of said plate members in opposing directions, and control means including a shaft coaxial with said assembly and extending from the device for external actuation and camming mechanism including a bi-symmetrical cam longitudinally displaceable for translating reciprocation of said shaft in either rotational direction through a disengagement angle required for disengagement of said terminals from a pad plus turn through a net angle equal to that between successive pads on the assembly into a corresponding change of pad in circuit with said connectors, wherein the turn of said control means through the disengagement angle initially effects the displacement of said plate members in unison to pad disengagement which with subsequent substantial continuity of direct turn actuation through the

net angle thereupon causes the repositioning of said assembly by one step through the shaft turn for operative circuital engagement of said corresponding pad with the connectors, and then effecting subsequent reengagement of said connectors with the newly selected pad.

30. A step attenuator as claimed in claim **29**, in which said mechanism contains spring means arranged to normally bias the mechanism into its stable relation and the plate members into full pad engagement position for their associated terminal connectors.

31. A step device as claimed in claim **29**, in which said mechanism incorporates drive roller means operated by said shaft and in coaction with said bi-symmetrical cam to displace said plate members longitudinally upon the initial phase of the shaft turn through the disengagement angle in either direction and operate the members into pad disengagement position, and further contains spring means arranged to normally bias the mechanism into its stable relation and said plate members into full pad engagement position for their associated terminal connectors upon the final phase of the shaft turn through the net angle for the new pad reselection.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,219,953 November 23, 1965

Bernard Schwartz

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 9, line 35, for "presses connector" read -- presses said connector --; column 11, line 75, for "as elected" read -- a selected --.

Signed and sealed this 6th day of September 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents