

June 12, 1951

R. E. CHARLES
RADIO-FREQUENCY SWITCH

2,556,869

Filed May 16, 1947

5 Sheets-Sheet 1

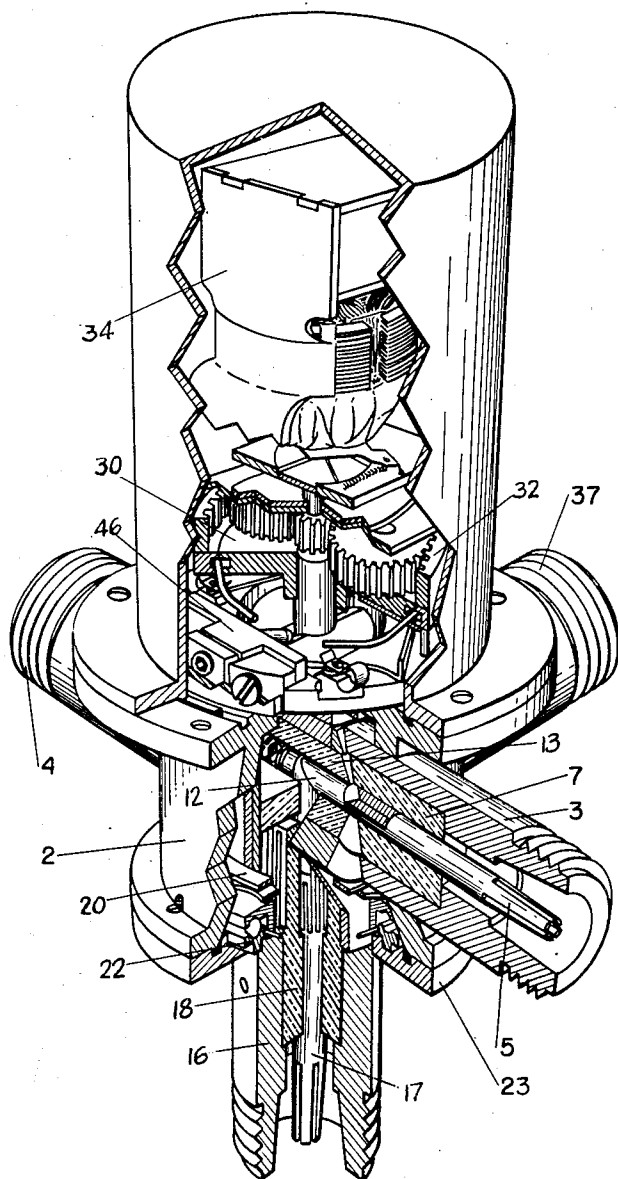


FIG. 1

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5 Sheets-Sheet 2

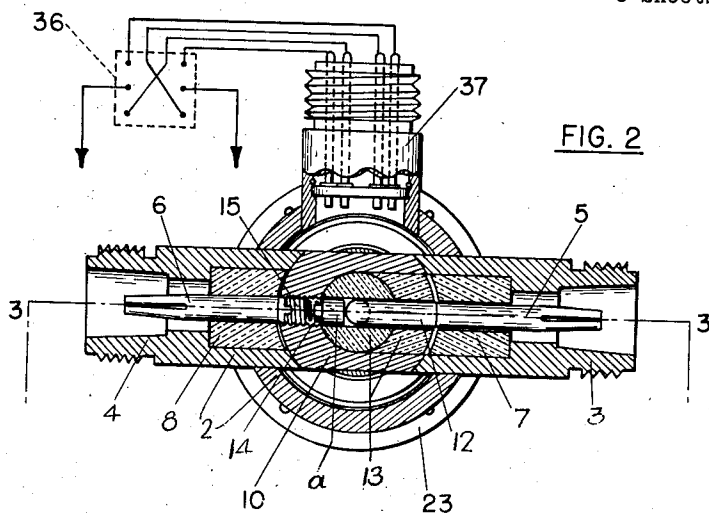


FIG. 2

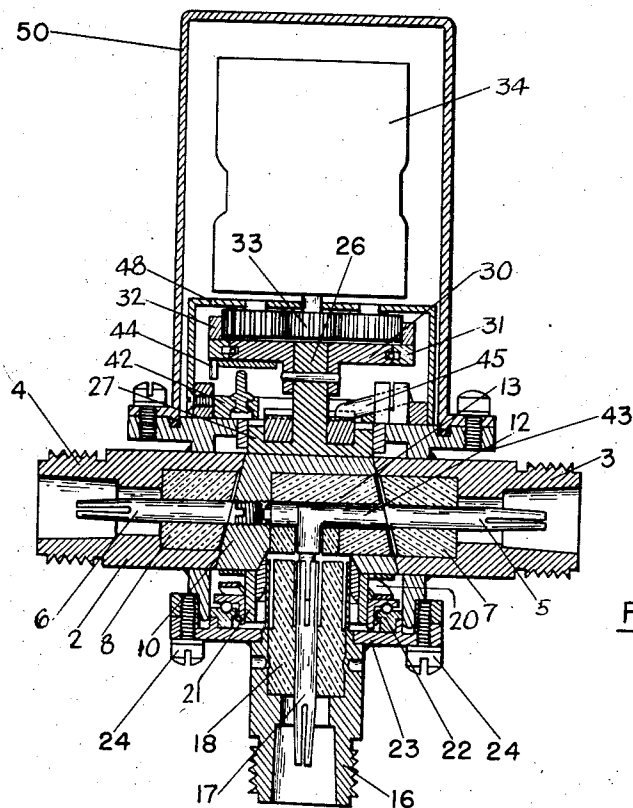


FIG. 3

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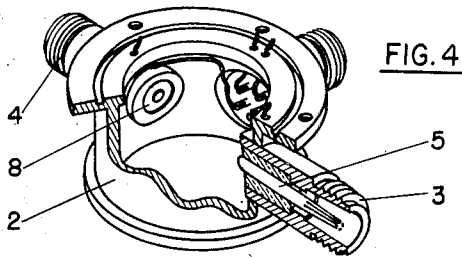


FIG. 4

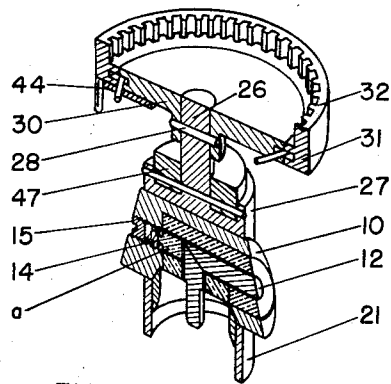


FIG. 5

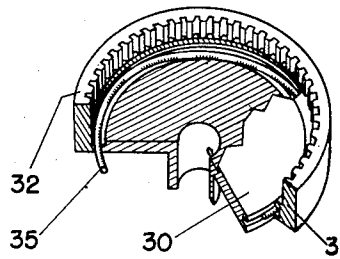


FIG. 6

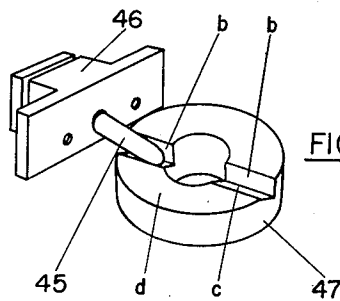


FIG. 7

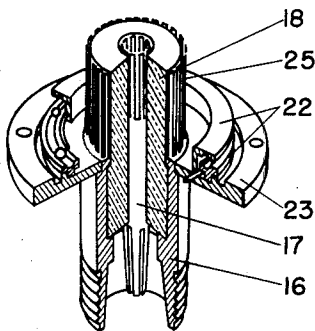


FIG. 8

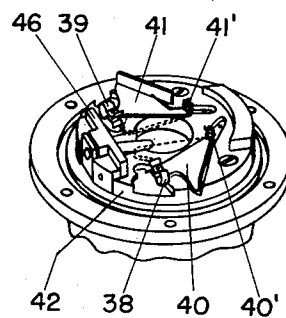


FIG. 9

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RADIO-FREQUENCY SWITCH

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5 Sheets-Sheet 4

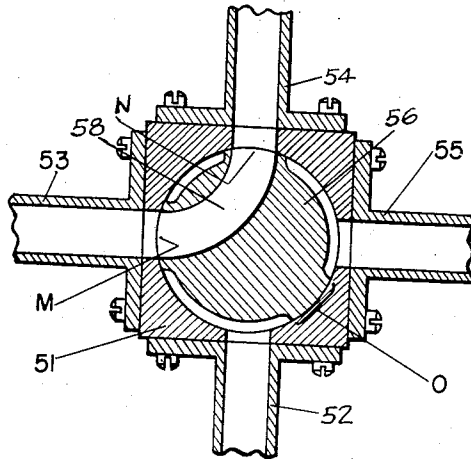
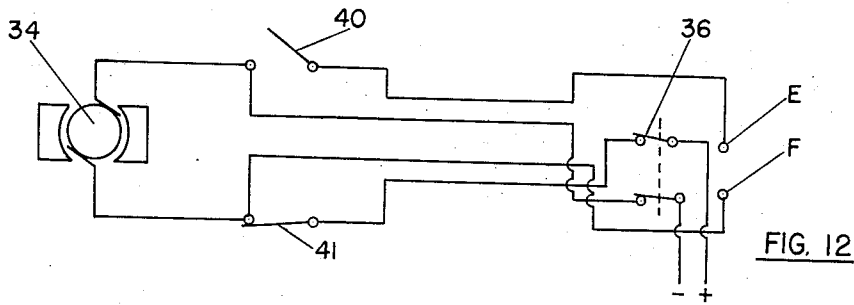


FIG. 10

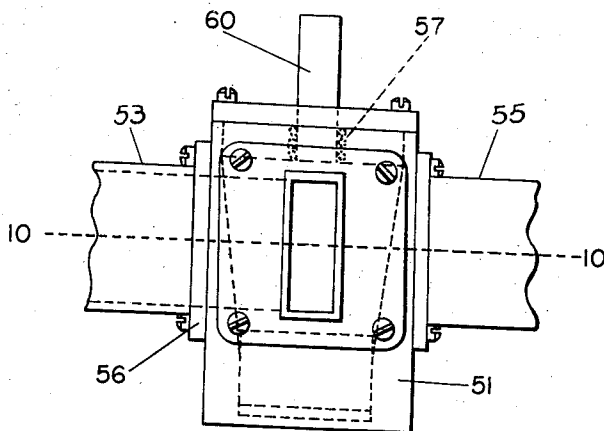


FIG. 11

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RADIO-FREQUENCY SWITCH

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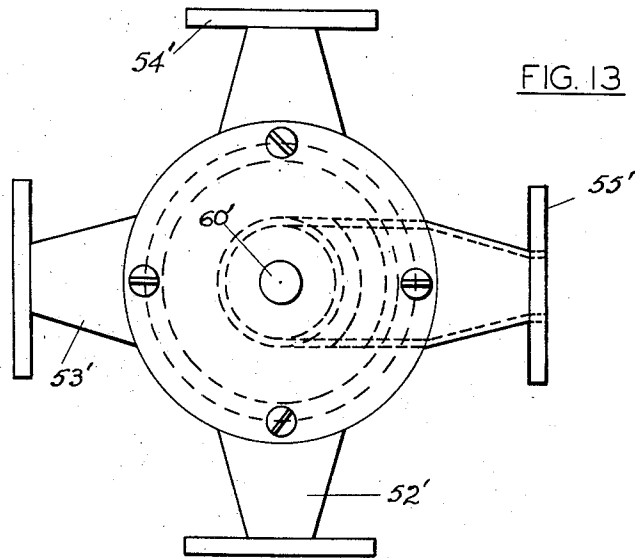


FIG. 13

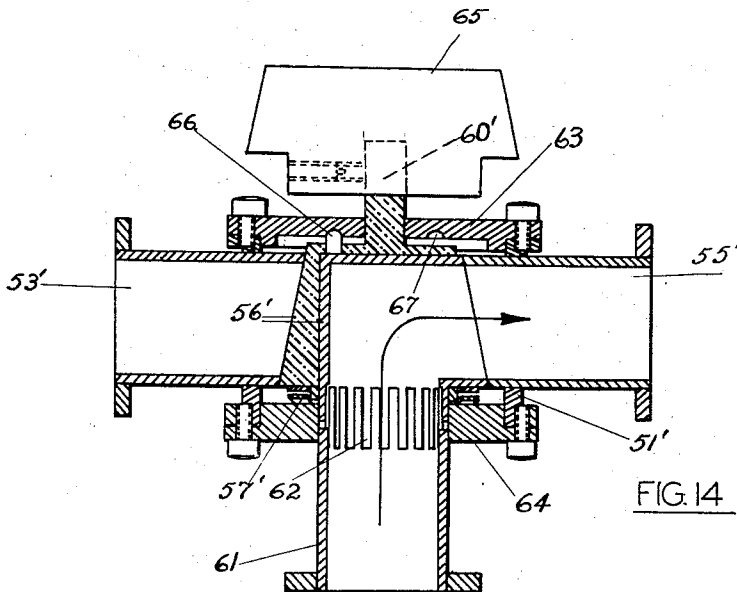


FIG. 14

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UNITED STATES PATENT OFFICE

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RADIO-FREQUENCY SWITCH

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5 Claims. (Cl. 200—153)

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The art of transmission of very high frequency alternating electric currents has become highly developed within the last decade through the introduction of the coaxial line and the elimination of electrical losses which have attended the use of more primitive transmission techniques. Coaxial transmission lines may be described as two-wire electrical power lines made up of a tubular outer conductor containing a solid wire inner conductor, various means being used to maintain constant insulation and central positioning of the inner conductor and, in some cases, flexibility of the line as a whole.

High frequency voltages and currents do not act in accordance with the customary concepts of two-wire electrical power transmission, and the success of coaxial transmission depends upon consistency of conductor dimensions, relative positioning, and the dielectrics present in the coaxial line itself. Any physical discontinuities in the structure of a coaxial line create standing waves, with consequent power losses as a result of wave reflections caused by such discontinuities. Switching facilities are, of course, desirable in coaxial transmission systems for various reasons as, for example, to switch an antenna between a radio transmitter and receiver, as in radio telephone work, or to switch a radio transmitter or receiver from one antenna to another. Because of the difference in requirements of coaxial transmission, as compared to that of the more common commercial power circuits, switching devices for these high frequency lines must meet conditions very different from those in circuits transmitting low frequencies. In the latter a good electrical contact is the chief requirement. While this also is important in radio frequencies, it is equally important that switching apparatus used for the latter shall not introduce significant discontinuities or changes in characteristic line impedance. Power losses which might result from improperly designed switching apparatus should be entirely eliminated.

Other factors desirable in a satisfactory coaxial switch are low values of cross talk, or unintentional electrical interaction between cables not actually switched together. In some cases it is desirable, also, to provide for the short-circuiting of cables not actually in use at all positions of the switch. Compactness of design and light weight are very desirable for air craft and portable installations and a motor drive for the switches should be provided in order to permit flexibility of installation, to eliminate excess cabling, and for ease of control.

Similar switching problems also are encoun-

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tered in connection with the newly developed wave guide power transmission technique as used in radar work, where essentially the same consideration must be given to the matter of dimensions and continuity.

To devise switching apparatus which will satisfy these requirements forms the chief object of the present invention.

The nature of the invention will be readily understood from the following description when read in connection with the accompanying drawings, and the novel features will be particularly pointed out in the appended claims.

In the drawings,

Fig. 1 is a perspective view of a switch constructed in accordance with this invention, some of the parts being broken away in order to illustrate concealed elements;

Fig. 2 is mainly a horizontal, sectional view of the switch shown in Fig. 1 but with some parts broken out, the plane of section being taken substantially along the axis of the inner conductor;

Fig. 3 is a vertical, sectional view of the switch shown in Fig. 1;

Fig. 4 is a perspective view of the base or body of the switch with some parts shown in section;

Fig. 5 is a similar view of half of the rotor of the switch and part of the mechanism for operating it;

Fig. 6 is a perspective sectional view of parts of the clutch unit which forms one element of the switch operating mechanism;

Fig. 7 is a perspective view of the stop mechanism for the rotor;

Fig. 8 is a perspective, sectional view of the coupling for connecting the rotor with the axial terminal;

Fig. 9 is a perspective view showing some of the details of the switch operating mechanism;

Fig. 10 is a horizontal, sectional view of a switch of the wave guide type embodying features of this invention;

Fig. 11 is a front elevation of the switch shown in Fig. 10;

Fig. 12 is a wiring diagram;

Fig. 13 is a top plan view of a modification of my invention; and

Figure 14 is a sectional elevation view of Fig. 13.

Referring first to Figs. 1, 2 and 3, the construction there shown comprises a switch body 2 including a metal shell provided at its opposite ends with screw-threaded coupling elements 3 and 4 which form the outer elements of a coaxial conductor or conductors. The inner conductors are shown at 5 and 6, respectively, and they are insulated from the outer conductors by dielectric

elements 7 and 8. Formed centrally in said body is a tapered or frusto-conical bore or socket, at the surface of which the coaxial stationary contacts of the switch terminate, these contacts being surface portions of the metal body 2 and the inner end surfaces of the conductors 5 and 6.

Mounted in the axial bore or socket of the switch body is a rotor tapered to fit the taper of the socket. It comprises a section of a coaxial conductor, the outer element of which is a metal shell 10, while its inner element is a conductor 12 including a radial arm and a vertical arm extending downwardly along the axis of the rotor. These parts 10 and 12 are separated by an insulating core 13 and those faces of the conductors at the right-hand end, Figs. 2 and 3, of the rotor, form coaxial contacts shaped and positioned for selective mating engagement with either of the two sets of stationary coaxial contacts above mentioned and which are mounted in the switch body.

Preferably the inner conductor 12 of the rotor has some radial freedom of movement in the direction of its horizontal arm, and it is backed up by a short plug *a*, Figs. 2 and 5, against which a spiral spring 14 bears, this spring, in turn, being backed up by a screw plug 15 threaded into the shell 10 of the rotor. This arrangement, therefore, forces the inner conductor radially in a direction to make a firm wiping contact with the inner conductor of either of the stationary terminals with which it is brought into register.

The input current is led axially into the switch body through a coupling, one part of which consists of the fitting 16, Figs. 1 and 3, this fitting, like those shown at 3 and 4, being adapted to cooperate with one end of a coaxial cable coupling member of a common form. In this fitting 16 the center conductor 17 is separated from the outer conductor by an insulator 18, and the upper end of this center conductor is shaped to form one member of a slip joint, the other member of this joint being the end portion of the downwardly extending arm of the rotor conductor 12. This slip joint is made such that the conductor 12 can revolve around the axis of the rotor while maintaining firm electrical contact with the stationary conductor 17.

In order to produce good conduction through the stationary and movable contacts of this switch, when in mating engagement, the taper of the rotor and its socket in the switch body are made rather steep, say in the neighborhood of 20° to 30° for the included angle, and a spring washer 20 bears against the lower end of the rotor where it forces it yieldingly upward and serves to maintain it normally in firm engagement with its seat in the switch body. This spring encircles, and is centered by, a metal sleeve 21 which extends downwardly from the rotor body, and a ball thrust bearing 22 backs up the spring 20 and is, itself, supported on an end plate 23 which is secured to the switch body 2 by screws 24—24, Fig. 3.

The end plate and the metal member of the connector 16 preferably are either made integral or are welded together. Extending upwardly from the upper end of the part 16 is a split metal sleeve 25, best shown in Fig. 8, which fits releasably into the sleeve 21 of the switch body and makes a firm, but yielding, contact with it, these parts forming the outer conductor of the axial input coupling.

It should be observed that the end of the inner rotor conductor 12 normally projects slightly

beyond its insulation and the tapered face of the rotor. Also, that the contact ends of the inner radial conductors 5 and 6 project inwardly slightly beyond the tapered inner face of the socket in the switch body. This is also true of the contacting surfaces of the outer tubular terminals of said body. Consequently, when the rotor is revolved to bring its coaxial contacts into mating engagement with either the right or left contacts of the stationary terminals, the insulating surfaces of the switch body and the rotor are not in contact with each other. Thus the radially directed components of the pressure which holds the tapered rotor in its seat are exerted almost exclusively on the two pairs of contacts in axial engagement with each other and on the stationary contacts diametrically opposed to those just mentioned and which back up the rotor and hold the working contacts in good current-transmitting relationship to each other. Contributing to this result also is the fact that the lateral sides of the rotor at right angles to the horizontal axis of the inner conductors 5 and 6 are spaced well away from the inner wall of the socket, as will be evident from an inspection of Fig. 2.

As above stated, it is desirable to have the switch power operated as, for example, to facilitate remote control. For this purpose the shell 10 of the rotor is extended upwardly, or has rigidly secured to it, a projecting portion forming a stem 26 and a circular flange 27, best shown in Fig. 5. Secured to the stem 26 by means of a tapered pin 28 is the inner member 30 of a friction clutch, the outer member 31 of which is either made integral with, or is secured rigidly to, an internal gear 32, Figs. 3, 5 and 6. Meshing with this gear are two intermediate gears driven by a pinion 33 which is secured fast on the shaft of a small direct current motor 34 having permanent field magnets. Consequently, when the motor is running, the gear 32, stem 26 and rotor 10 will be revolved in either a clockwise or counter-clockwise direction, depending upon the position of the switch controlling the supply of energy to the motor.

The two parts of the clutch 30 and 31 are grooved on their meeting faces, as shown in Figs. 3 and 5, to receive a wire spring 35 which normally exerts enough friction on the two clutch members to make them rotate in unison. If the torque transmitted through the clutch becomes excessive, the outer member 31 will slip on the inner clutch disk 30.

Current is supplied to the motor 34 from any suitable direct current source, such as a 24 volt battery, through a reversing switch 36 and suitable connections leading through the outlet 37 at the back of the switch body 2 to the stationary terminals 38 and 39, respectively, Fig. 9, of two small switches 40 and 41 which are mounted on an insulating disk 42 secured on the upper face of a top plate 43 which is welded to the body 2. These two switches are connected to the reversing switch in the manner readily understood from Fig. 12, so that the motor will revolve in one direction or the other, depending upon the position of the switch 36. The switches 40 or 41 are limit switches, as will presently be explained. Small springs 40' and 41', Fig. 9, tend to hold their respective switches closed and either one is opened by swinging it inwardly.

In this particular construction the rotor 10 is revolved through 180° and is then stopped. When it is next started up, it is rotated in the opposite

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direction through 180° and is stopped again. In order to produce this operation a switch-actuating pin 44, Figs. 3 and 5, is secured to the inner clutch disk 30 in the proper position to engage the outer side of the flange on either switch 40 or 41 and to swing the particular switch so engaged inwardly to open it and deenergize the motor.

In addition to cutting off the current from the motor by opening one or the other of these switches, other means must be provided to stop it in exactly the desired position. For this purpose a stop pin 45 is mounted on a block 46, Figs. 1 and 7, in an inclined position where its rounded inner end bears on the lower surface of a stop-and-cam disk 47 which is pinned to the stem 26, as shown in Fig. 5. This disk is provided with two stop surfaces b—b at the base of each of which is a notch with an inclined surface, one of which is shown at c in Fig. 7, and the inner edges of these notches are connected by a flat face d. Consequently, when the motor 24 is started, the action of one of the inclined surfaces c on the stationary pin 45 produces initially a depression or downward movement of the rotor against the action of the spring 21. This movement of the rotor, even though relatively slight, unseats and disconnects the tapered surface of the rotor from the walls of the tapered socket in the switch body. It occurs at the very start of the rotative movement of the rotor so that thereafter relatively little power is required to complete the rotation of the switch through an angle of 180°. At that time the vertical wall of the shoulder b strikes the pin 45 and definitely stops any further movement of the rotor around its axis in the direction in which it has been swinging. The position of the stop pin 44 on the clutch disk 30 is such that just before this action occurs the switch 40 or 41, through which power is flowing to the motor, is opened, thus cutting current off the motor. While these rotating parts are relatively light in weight, there is some tendency for an over-run, and such would occur if it were not for the action of the stop shoulder b and the pin 45. The momentum tending to create such an over-run is absorbed by the slipping of the clutch ring 34 on its cooperating clutch disk 32—33.

When the motor switch 36 is thrown in the opposite direction to start up the motor 24 again, the same operations above described are performed, the rotor being first depressed to unseat it, and it then makes a half revolution, at which time it is stopped; the motor current is cut off; and the spring 20 reseats the rotor in its tapered socket. Thus the indexing of the switch is performed very accurately with a very simple mechanism, and the parts are protected from damage.

With the switches positioned as shown in Fig. 12, current flows from the positive side of the supply line through one leg of the reversing switch 36, through the limit switch 41, the motor 34, and back through the other leg of the reversing switch to the negative terminal. Just before the motor stops, the limit switch 41 will be opened by the pin 44, as above described. To reverse the motor, the switch 36 is reversed, when current will flow from the positive side of the line through the contact e, limit switch 43, motor 34, the return side of the circuit to the contact f, and through switch 36 to the negative terminal. As above stated, each of the switches 40 and 41 is closed by its spring as soon as the stop pin 44 moves away from it.

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In this particular construction the motor is supported on a bracket 43, Fig. 3, secured to the base 43, and the entire switching mechanism operated by it is enclosed in a casing 50 which is screwed to said base 43.

A very similar construction can be used as a wave guide, as shown in Figs. 10 and 11. Here the switch body 51, made of metal or some equivalent conducting material, is provided with four radiating connections 52, 53, 54 and 55, any one of which may be used as an inlet or input terminal and any one of the others as an output connection. The body 51 is provided with a tapered seat in which is mounted a rotor 56, normally held seated by the coiled spring 57, Fig. 11. The waves are transmitted from one terminal to another through a curved channel 58 having ends angularly spaced from each other to make mating engagement with any two adjacent radial connections 52 to 55, inclusive. Projecting upwardly from the rotor 56 is a stem 59 which may be operated manually or driven by a motor, as in the construction above described.

A novel feature of the switch here shown is the construction of the tapered rotor 56 so that it has a three-point bearing with the socket in the body 51. It will be seen from an inspection of Fig. 10 that the portions of this rotor immediately surrounding the ports M and N bear firmly against the wall of the socket. Another area O, equidistant circumferentially from M and N, also bears against the socket wall. Intervening areas of the rotor are, however, spaced from said wall. Thus the pressure created by the spring 57 is divided equally between these three areas M, N and O, thus minimizing leakage which otherwise might occur in the neighborhood of the ports M and N.

Another form of wave guide embodying this invention is shown in Figs. 13 and 14, the former being a plan view without the knob, while the latter is a vertical section taken substantially through the axis of the switch. It comprises a body 51' provided with four tubular radial terminals shown, respectively, at 52', 53', 54' and 55'. This body is provided with a tapered seat to receive a rotor 56' which has an angular passage therethrough, one end of which registers with an axially extending tubular terminal 61, the rotor and the terminal being connected by a flexible joint 62 similar to that used to connect the parts 13 and 16 in Fig. 3. The rotor is held in its operative position between end plates 63 and 64 which are screwed to the body 51' and a spring 57' is interposed between the end plate 64 and the rotor where it serves to hold the latter yieldingly in its normal or seated position. Extending upwardly from the rotor is the stem 63' to which a knob 65 can be secured for convenience in operating the switch. Also projecting upwardly from the rotor is a pin 66 adapted to enter any one of four depressions or sockets in the end plate 63, one of which sockets is shown at 67 in Fig. 14. These sockets are so positioned as to register the rotor with any selected one of the radial terminals.

In using this switch the rotor 56' can be adjusted to connect the input terminal 61 with any one of the four radial output terminals 52' to 55'. In making this adjustment of the rotor the knob is utilized to depress the rotor so as to disengage the pin 66 from its socket 67 and also to turn the rotor. As it is about to come into alignment with the desired radial terminal, the downward pressure on the knob is released so that when its

outlet end arrives in register with the selected terminal, the pin 66 will snap into the proper socket 67 due to the action of the spring 57'.

With this construction switching can be made to a greater number of lines in a switch structure of a given size than would be possible with the embodiment of the invention illustrated in Figs. 10 and 11.

It should also be noted that in the construction shown in Figs. 13 and 14 the passages in the radial arms are circular in cross-sectional form adjacent to the rotor 56', but their shape is gradually changed so that the ends of these terminals are of rectangular cross-sectional form to cooperate with tubular conductors of this form. In this sense these sections 52' to 55' may properly be termed "transformer sections." In addition, the rotor is shaped in horizontal section, as shown in Fig. 2, so as to obtain the localized contact advantage.

From the foregoing it will be evident that this invention provides a radio frequency switch in which leakage of current and power losses are reduced to negligible values. The same is true of "cross-talk". In addition, the invention may be embodied in designs exceptionally compact and light in weight. While in the particular form shown in Figs. 1, 2 and 3 only one input and two output terminals are provided, it is obvious that this number can be enlarged merely by modifications in design. Thus the invention may be embodied in other forms without departing from the spirit or scope thereof.

Having thus described my invention, what I desire to claim as new is:

1. A radio frequency coaxial switch comprising a body provided with a socket, a rotor positioned in said socket, a center coaxial conductor section carried by the rotor and extending transversely of the axis thereof with one end exposed at a lateral surface of said rotor to form a coaxial rotor contact, a stationary coaxial terminal mounted radially with respect to said rotor in said body and having a coaxial contacting surface at the surface of said socket, said stationary and rotor contacts being positioned for mating engagement with each other at a predetermined point in the movement of said rotor around its axis, insulation surrounding said center conductor but permitting limited freedom of bodily movement of said conductor radially of the rotor, a portion of said insulation comprising a movable plug having an inner wall bearing against the inner end of the radially extending portion of said conductor and a spring bearing against an outer wall of said plug, said spring urging said conductor, through said plug, radially outward so that it makes a firm engagement with the center contact of said stationary terminal when in mating engagement with it.

2. A radio frequency coaxial switch comprising a body provided with a tapered socket, a tapered rotor positioned in said socket, a center coaxial conductor carried by the rotor and having a section extending transversely of the axis thereof with one end exposed at a lateral tapered surface of said rotor and forming a coaxial rotor contact, a stationary coaxial terminal mounted radially with respect to said rotor in said body and having a coaxial contacting surface at the tapered surface of said socket, said stationary and rotor contacts being positioned for mating engagement with each other at a predetermined point in the movement of said rotor around its axis, said center conductor having another section extending

axially of said rotor, said sections having limited freedom of bodily movement relative to said insulation radially outward of the rotor, a movable plug of insulation having an inner wall bearing against the inner end of the radially extending section of said conductor and a spring mounted outside the path of current flow through said conductor and bearing against an outer wall of said plug and urging said conductor, through said plug, radially outward so that it makes a firm engagement with the center contact of said stationary terminal when in mating engagement with it.

3. A switch according to claim 2, in which said rotor has opposite end portions snugly fitting against the wall of the socket and the surface of the rotor which is between the end portions being spaced from the wall of the socket, whereby contact area of the rotor with the socket is mainly at the end regions of the rotor.

4. A switch according to preceding claim 2, in which the surfaces of said rotor between the area closely surrounding said rotor contact and that diametrically opposed to it are reduced in radial dimensions, thereby confining the pressure of the rotor on the wall of the socket mainly to the switch contact areas and points at the opposite side of the rotor axis from said contact areas.

5. A radio frequency coaxial switch comprising a body provided with a tapered socket, a tapered rotor positioned in said socket and including a center coaxial conductor with a section of the coaxial conductor positioned transversely of the axis of the rotor with one end exposed at a lateral tapered surface of said rotor and forming a coaxial rotor contact, a stationary coaxial terminal mounted radially with respect to said rotor in said body and having coaxial contacting surfaces at the tapered surface of said socket, said stationary and rotor contacts being positioned for mating engagement with each other at a predetermined point in the movement of said rotor around its axis, the center conductor in said rotor having an arm extending along the axis of the rotor, an end plate secured to said switch body adjacent to one end of the rotor, and a coupling member projecting axially from said plate, said member including a flexible sleeve contact forming the outer conductor of an input connection to the switch, and a flexible sleeve contact forming the center conductor of said input connection to the switch, said center conductor having a rotatable connection with said arm of the center conductor of the rotor.

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