Sept. 19, 1967 O. A. GURAYDIN **3,342,966**

VACUUM COAXIAL RELAY

Filed Feb. 1, 1965 3 Sheets-Sheet 1

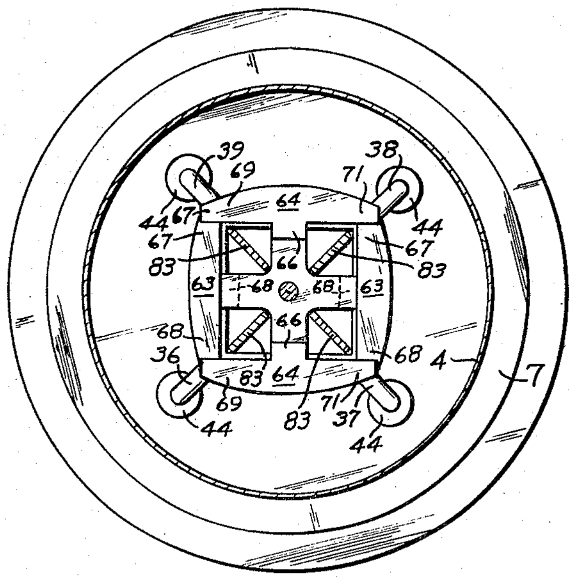

Fig-2

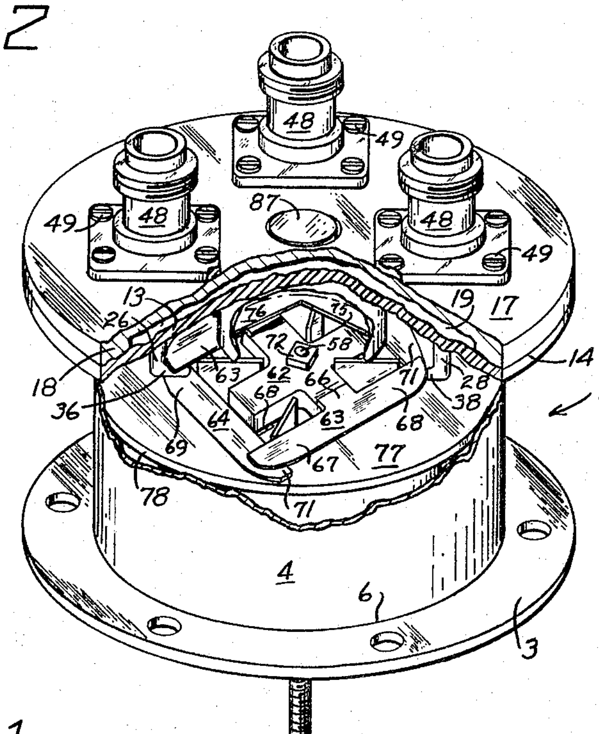

Fig-1

INVENTOR.
ORHAN A. GURAYDIN
BY
John J. Leavitt

VACUUM COAXIAL RELAY

Filed Feb. 1, 1965 3 Sheets-Sheet 2

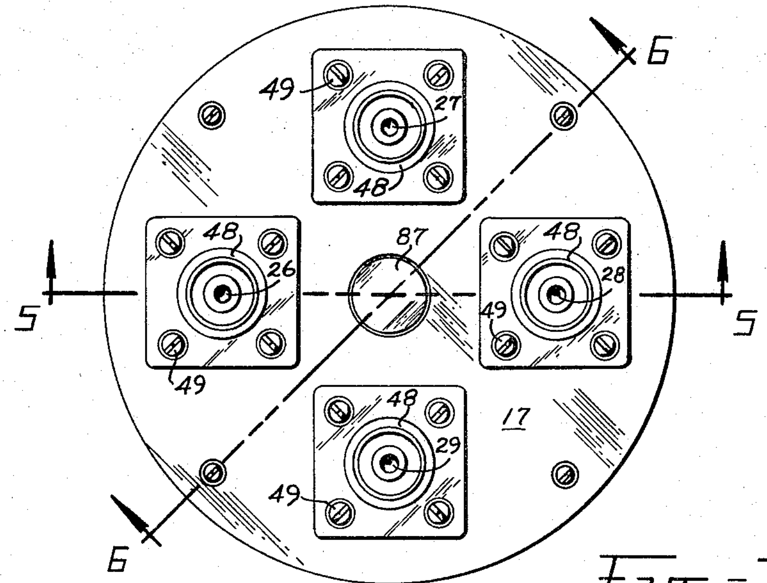

Fig - 3

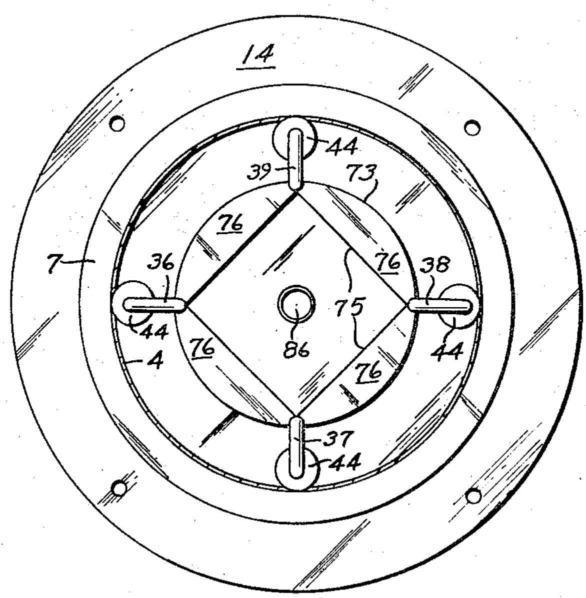

Fig - 4

INVENTOR.
ORHAN A. GURAYDIN
BY John J. Leavitt

VACUUM COAXIAL RELAY

Filed Feb. 1, 1965 3 Sheets-Sheet 3

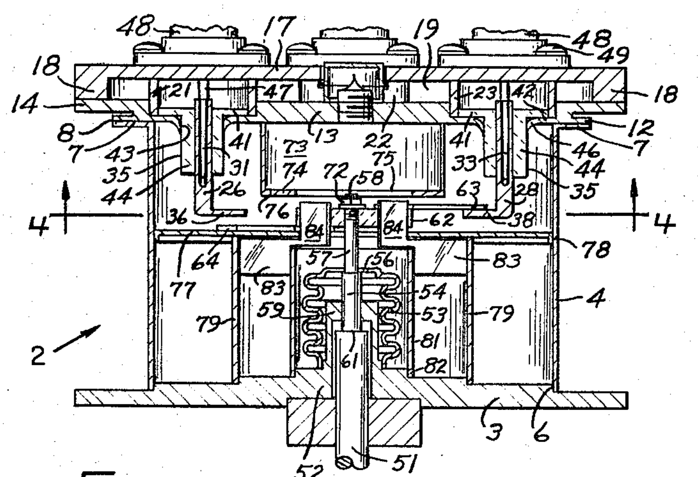

Fig-5

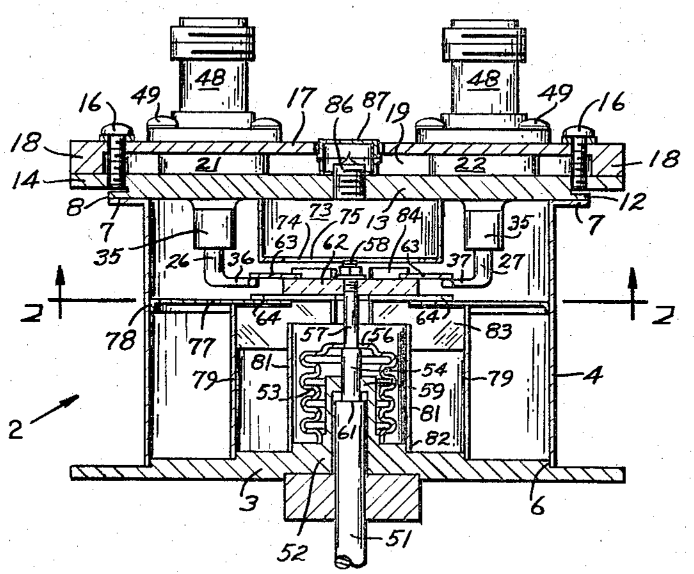

Fig-6

INVENTOR.
ORHAN A. GURAYDIN

BY

John J. Leavitt

United States Patent Office 3,342,966 Patented Sept. 19, 1967

3,342,966
VACUUM COAXIAL RELAY

Orhan A. Guraydin, San Jose, Calif., assignor to Jennings Radio Manufacturing Corporation, San Jose, Calif., a corporation of Delaware

Filed Feb. 1, 1965, Ser. No. 429,336
19 Claims. (Cl. 200—153)

ABSTRACT OF THE DISCLOSURE

A vaccum coaxial relay hermetically sealed with a moveable contact structure comprising a cruciform dielectric support member and resilient contact blade mounted on each end of the support member.

This invention relates to coaxial relays, and particularly to a vacuum coaxial relay of the cross-point type.

Cross-point matrices are useful in the communication arts to connect a single receiving or transmitting station with one or more receiving or transmitting antennae. It has been the practice in conventional matrices to utilize a plurality of separate individually controlled relays to accomplish this function. This has resulted in space-consuming complicated arrays, and in the necessity of an unwieldy control circuit to control the multiplicity of relays incorporated in such matrices. It also results in needless expense and multiplication of parts. It is therefore one of the principal objects of the present invention to provide a vacuum coaxial relay of the two-pole, two-position type, operable to provide a selectivity and versatility in cross-point switching not heretofore available with known cross-point vacuum relays.

One of the disadvantages of conventional coaxial relays has been the existence of undersirable inductive capacitance resulting in "cross-talk" between adjacent circuits. This problem is a difficult one because solutions to this problem usually create other undesirable problems such as difficulty of fabrication or disruption of the voltage standing wave ratio (VSWR). Accordingly, another principal object of the invention is to provide a cross-point type coaxial relay designed to eliminate "cross-talk" between adjacent circuits while providing a low voltage standing wave ratio in the order of 1:1.085.

Another disadvantage found in conventional vacuum coaxial relays is the absence of characteristics which render such relays suitable for operation over a wide band of the frequency spectrum. It is therefore a still further object of the invention to provide a cross-point type vacuum coaxial relay suitable for wide band operation in the frequency range, say, from 0 to 600 megacycles at power ratings up to 5 kilowatts.

Because communication installations are expensive in terms of time and materials, there is great reluctance to modify an existing system to incorporate new components unless such new components fit into the framework of cost and function originally planned for the installation. Any new device, such as a new vacuum coaxial relay, is required to fit conveniently into the original concept of design of the system and associated equipment which the systems manufacturer already has operating in the field, or which it is presently designing for future installation. Accordingly, it is a still further object of the invention to provide a coaxial relay of the cross-point type which will readily accommodate standard coaxial connectors, or a combination thereof, to render the relay compatible with existing systems.

Coaxial matrices of conventional design have heretofore utilized devices such as relays and connecting hardware which rendered such matrices voluminous and heavy, thus precluding or restricting their use in airborne

equipment where space and weight are important factors. It is therefore another object of the invention to provide a vacuum coaxial relay of the two pole-two position cross-point type which is compact in configuration, low in weight, and which is provided with standard coaxial fittings in a manner to minimize the space requirements of a matrix in which it is incorporated.

The economical manufacture of reliable vacuum electronic components of any type is a difficult task, principally because the design of such components requires skilled mechanical and electronic engineers capable of producing a component design that can be mass-produced and still perform the intended functions. Additionally, the manufacture of vacuum devices requires considerable quality control and careful handling of the parts prior to their assembly, and considerable care in the necessary processing and testing of each device after it has been assembled. Accordingly, it is a still further object of the invention to provide a vacuum coaxial relay which is made up from parts which may be accurately fabricated at low cost and expeditiously assembled into a composite whole by mass production techniques.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be apparent from the following description and the drawings. It is to be understood, however, that the invention is not limited to the embodiment illustrated and described, as it may be embodied in various forms within the scope of the appended claims.

Referring to the drawings:

FIG. 1 is a perspective view of the vacuum coaxial cross-point relay, portions of the envelope being broken away to disclose the underlying parts.

FIG. 2 is a horizontal cross-sectional view taken in the plane indicated by the line 2—2 in FIG. 6, and showing the relationship of the movable contact assembly to the fixed contacts.

FIG. 3 is a top plan view illustrating the relationship of the coaxial fittings on the fixed contact support plate.

FIG. 4 is a horizontal cross-sectional view showing the fixed contact support plate, similar to FIG. 2, but with the movable contact assembly removed to illustrate the relationship between the fixed contacts and one of the ground planes which extends into the envelope. The plane of the section is indicated by the line 4—4 in FIG. 5.

FIG. 5 is a vertical cros-sectional view taken in the plane indicated by the line 5—5 in FIG. 3. A portion of each coaxial connector and the actuator shaft are broken away to reduce the height of the figure. The view illustrates the manner in which the ground conductor of each coaxial connector is extended to form a smooth impedance matching transition from the transmission line outside the envelope to the relay parts within the relay.

FIG. 6 is a vertical cross-sectional view taken in the plane indicated by the line 6—6 in FIG. 3 and illustrates the detachable relationship of the cover plate and coaxial connectors.

Broadly considered, the vacuum coaxial relay of the cross-point type which forms the subject matter of the invention comprises an evacuated metallic envelope, closed at one end by a base plate which supports an actuator mechanism, a moveable contact assembly, and various shield structures, one of which functions as a ground plane extending into the envelope. At its other end the envelope is closed by a support plate on which are insulatedly mounted a plurality of conductors terminating within the envelope in fixed contact points, selected ones of which are adapted to be engaged and disengaged by the movable contacts. The end plates are heremetically united and held in spaced parallel relation by a tubular metallic shell. The fixed contact points comprise a plurality of circularly arranged horizontally extending fixed contact members, spaced so that selected pairs of movable contact points may be enegaged therewith to make and break cross circuits through the envelope. Each of the fixed contact points and the conductor to which it is connected is associated with a conventional coaxial fitting suitably mounted on one of the end plates.

In terms of greater detail, the vacuum coaxial crosspoint relay of the invention comprises an evacuated metallic envelope designated generally by the numeral **2**, and is fabricated from a stepped base plate **3**, shown best in FIGS. 5 and 6, a tubular metallic shell **4** brazed to the base plate as shown at its bottom end **6**, with the opposite end of the shell provided with a radially outwardly extending seal flange **7**, the peripheral edge of which is heliarc welded as at **8** to a juxtaposed and contiguous seal flange **12** which is an integral part of the fixed contact support plate **13**. Base plate **3**, shell **4** and support plate **13** are preferably fabricated from oxygen-free high-conductivity copper.

The fixed-contact support plate is provided with a second radially outwardly extending and integral anchor flange **14**, bored and threaded to receive a multiplicity of circularly arranged cap screws **16**, shown best in FIGS. 3 and 6, whose function is to a accurately position and clamp cover plate **17**, having a peripheral cylindrical flange **18** as shown, to the anchor flange **14** of support plate **13**. The height of flange **18** provides a space **19** between the cover plate and fixed-contact support plate within which are conductively clamped ground conductor tubular shells **21**, **22**, **23** and **24** operatively associated, respectively, with coaxial inner conductor members **26**, **27** and **29**.

The coaxial inner conductor members include tubular end portions **31**, **32**, **33** and **34**, respectively, two of which are shown in FIG. 5, and each of which is heremetically brazed in the central bore of an associated dielectric seal and transition member **35**. The other ends of the coaxial inner conductor members are provided with integral radially inwardly extending fixed contact points **36**, **37**, **38** and **39**, all lying in substantially the same plane. Each dielectric member **35** is provided with a radially outwardly extending flange **41** which overlies an annular flange **42** integral with support plate **13**. The flange is formed by rabbeting the plate about an aperture **43** therein and through which a tubular portion **44** of the dielectric seal and transition member extends. Hermetic sealing of the transition member **35** to the flange **42** is effected by brazing a cylindrical lip portion **46** formed on the inner periphery of the annular flange to a metallized band formed about the tubular portion **44** closely adjacent flange **41**. In this manner the differences in thermal expansion and contraction between the metal and dielectric parts has a minimum effect.

The tubular end portions of the coaxial inner conductors extend into the outer or ground conductor shells **21**, **22**, **23** and **24**, and are adapted to be slidably and conductively engaged by the inner conductor portion **47** of a coaxial transmission line coupling or connector member **48** shown best in FIGS. 1, 3 and 6. The dielectric seal and transition members form electrically insulating units, insulating the inner conductor members from the grounded support plate **13** and associated structure. Accordingly, all of the actuating mechanism of the relay, including the outer metallic envelope, is at ground potential, thus enabling the relay to be handled with safety. The coupling members **48** are preferably detachably secured to the cover plate by appropriate screws **49**, shown best in FIG. 3.

The actuating mechanism of the relay comprises an axially extending actuator shaft or stem **51** extending into the envelope and slidably supported over a portion of its length by bearing member **52** forming an integral extension of base plate **3**. An expansible metallic bellows **53** surrounds a reduced-in-diameter inner end portion **54** of the actuator stem and has its inner end **56** brazed to the actuator stem intermediate its ends. The portion **57** of the stem extending into the envelope beyond the inner end of the bellows is threaded on its inner end **58**. The reduced-in-diameter shaft portion **54** lies within the bellows outside the vacuum envelope and slidably engages a bearing and stop flange **59** which forms an abutment against which the shoulder **61** on the shaft may abut to limit inward movement of the shaft when the shaft is actuated in this direction solely by atmospheric pressure. The outer open end of the bellows is brazed to a step in the base plate about the bearing member **52**.

On the inner end **58** of the actuator stem is supported a mobile contact assembly including a cruciform dielectric support plate **62** arranged perpendicularly with respect to the axis of the actuator shaft. The dielectric support plate **62** has appreciable thickness, in the order of about $\frac{3}{16}$'', and is shown best in FIG. 1, 2, 5 and 6. Adjacent the ends of each pair of its cruciform arms, which pairs of arms are substantially perpendicular to each other, but on opposite surfaces on perendicularly disposed pairs of arms, are brazed two pairs of conductive resilient contact blades **63** and **64**. As shown best in FIGS. 1 ,2, 5 and 6, the blades of the pair of contact blades **63** are spaced on opposite sides of the axis of the actuator stem and are brazed on the upper surface of the arm portion of dielectric member **62**. Each blade of the pair includes a central portion **66** brazed to an end portion of the associated arm of the cruciform dielectric member, and laterally extending thin resilient metallic finger portions **67** and **68** extending in opposite directions perpendicular to the long dimension of the arm on which it is attached, as shown best in FIG. 2.

The resilient contact blades **64** are likewise horizontally spaced on opposite sides of the axis of the actuator stem but are supported on the lower side of the cruciform dielectric member **62**. Each of these contact blades is provided with a central body portion **68**, which overlaps and is brazed to the end portion of the associated arm of the cruciform dielectric support member, and with laterally extending thin resilient metallic finger portions **69** and **71** extending in opposite directions perpendicular to the long dimension of the arm on which it is attached, as shown best in FIGS. 1 and 2.

The resilient contact blades **64** are likewise horizontally spaced on opposite sides of the axis of the actuator stem but are supported on the lower side of the cruciform dielectric member **62**. Each of these contact blades is provided with a central body portion **68**, which overlaps and is brazed to the end portion of the associated arm of the cruciform dielectric support member, and with laterally extending thin resilient metallic finger portions **69** and **71** extending in opposite directions perpendicular to the long dimension of the arm on which it is attached, as shown best in FIGS. 1 and 2.

An adjustable nut **72** threadedly engaging the upper end of the actuator stem fixes the position of the mobile contact assembly with respect to fixed contact points **36**, **37**, **38** and **39** so that these fixed contact points lie in the space between the resilient contact blades **63** and **64**. Accordingly, when the actuator stem is displaced in an axial direction by any appropriate means such as a solenoid (not shown), the mobile contact assembly moves up and down so as to bring first one pair of contact blades, such as **63**, into contact with two selected pairs of the fixed contact points, while when the mobile contact assembly is moved in the opposite direction, i.e., toward the support plate **13**, the contact blades **64** are brought into conductive contact with a different set of two selected pairs of fixed contact points.

Thus, as seen in FIG. 2, expansion of the bellows by atmospheric pressure, in the absence of an actuating mechanism which itself provides the limits of movement, will effect engagement and interconnection of the fixed contacts 38 and 39, as a pair, by one of the contact blades 64, to complete a circuit therethrough, while the fixed contact points 36 and 37, as a second pair, will be engaged and interconnected by the opposite contact blade 64 of the pair. On the other hand, when the actuator of the relay is energized, as by a solenoid, or by hand, to overcome atmospheric pressure and thus collapse the bellows to displace the pair of mobile contact blades 63 downwardly as viewed in FIG. 6, the pair of resilient contact blades 63 will conductively connect fixed contact point 38 to fixed contact point 37 as a third pair, and fixed contact point 36 to fixed contact point 39 as a fourth pair. It will accordingly be seen that a cross-point connection has been effected between the enumerated fixed contact points. It should be understood that while the actuator shaft has here been shown as responding to atmospheric pressure, an actuator mechanism similar to that disclosed in United States Letters Patent No. 3,145,278 may be utilized, where a spring is inserted to compensate for atmospheric pressure and the limits of travel are set by the actuator mechanism.

In order to eliminate "cross-talk" between the pairs of contact points and pairs of circuits that are in "open" condition, shielding means are provided within the envelope interposed between the pairs of resilient contact blades 63 and 64 in a manner to effect shielding of the contact blades of each pair from each other by providing a ground plane disposed therebetween.

This is accomplished by providing a hollow metallic shell-like ground member 73, shown best in FIGS. 5 and 6, brazed at one end to the underside of the support plate 13 and at its other end provided with a ground plate portion 74 having a square aperture 75. The portions 76 of the shell which define the aperture provide a ground potential abutment against which the resilient contact blades 63 abut when the relay has been actuated by atmospheric pressure or other means. The configuration of the metallic ground plate portion 74 cooperates with the fixed contact points and movable resilient contact blades to provide substantially constant impedance through the relay.

When the switch is actuated in the other direction, as by appropriate solenoid or other means (not shown) attached to the actuator stem, the mobile and resilient contact blades 64 are brought into resilient contact with an annular ground plate 77 brazed around its outer periphery as at 78 to the outer metallic shell 4, and supported adjacent its inner periphery on an axially extending tubular metallic shell 79 brazed to the base plate 3 as shown best in FIGS. 5 and 6. Concentrically disposed within the tubular shell 79, and surrounding the expansible bellows to form a sputter-shield therearound, is a third tubular metallic member 81, its lower end 82 brazed to a shoulder formed in the support plate 3, and its inner end extending freely in the direction of the mobile contact assembly 62. To complete the "cross-talk" shielding means, the relay is provided with radially extending thin metallic plates 83 shown best in FIGS. 1, 2, 5 and 6. The plates 83 are fixedly interposed conductively between the tubular shell 79 and the tubular member 81, and provide an upwardly extending portion 84 extending into the corner formed by two adjacent and perpendicular arms of the cruciform dielectric member 62 as shown best in FIGS. 1 and 2. While these metallic plates 83 are fixedly attached to and take on the polarity and potential of the ground shell 79, it is apparent that they do not come in contact with and are electrically spaced from the adjacent mobile and resilient contact blades 63 and 64. These metallic shield plates function to intercept and ground out any inductive capacitance which would otherwise cause "cross-talk" between the resilient contact blades of each pair of such blades which are in circuit.

One of the disadvantages of conventional vacuum coaxial relays has been the fact that in the transition from an air-dielectric coaxial transmission line to a vacuum-dielectric relay the abrupt change in impedance effects an abrupt change in the VSWR of the transmission line. Accordingly, in the relay illustrated, this transition from air-dielectric to vacuum-dielectric has been accomplished gradually so as to preclude reflection of the signal back through the transmission line by properly gauging the diameters of members 21, 73, 79, 81 and the configuration of mobile resilient contact blades 63 and 64, and the two ground planes 73 and 77. For instance, in actual tests, it has been demonstrated that the VSWR of the relay in all frequencies between 0 and 600 megacycles ranges between 1:1.01 to 1:1.085, thus remaining below an undesirable level. After assembly, evacuation of the envelope is accomplished through a tubulation 86, protected by a cap 87 as shown.

I claim:

1. A vacuum coaxial relay comprising an envelope including an actuator support plate forming one end of the envelope, a fixed-contact support plate spaced from the actuator support plate and forming the other end of the envelope, a tubular metallic shell hermetically disposed between said actuator and fixed contact support plates and forming the side wall of said envelope, a plurality of spaced conductors extending insulatedly and hermetically through said fixed contact support plate and terminating within the envelope in a plurality of spaced fixed contact points, a mobile contact assembly including a cruciform dielectric support member disposed within the envelope and including pairs of resilient contact blades arranged to conductively connect a plurality of pairs of said fixed contact points when the mobile contact assembly is moved in one direction and to conductively connect a plurality of different pairs of said fixed contact points when the mobile contact assembly is moved in the opposite direction, and an actuator assembly movably supported on said actuator support plate and engaging said mobile contact assembly to effect movement thereof in a selected direction.

2. The combination according to claim 1, in which a ground shell is mounted on said fixed-contact support plate whereby movement of said mobile contact assembly in one direction effects engagement of one pair of said resilient contact blades with said ground shell while another pair of said resilient contact blades conductively connects two pairs of said fixed contact points.

3. The combination according to claim 1, in which a ground plate extends transversely across the interior of said envelope on the side of said mobile contact assembly remote from said fixed-contact support plate whereby movement of said mobile contact assembly in one direction effects engagement of one pair of said resilient contact blades with said ground plate while another pair of said resilient contact blades conductively connects two pairs of said fixed contact points.

4. The combination according to claim 1, in which a plurality of coaxial connectors corresponding in number to said spaced conductors are detachably supported on the fixed-contact support plate in conductive association with said spaced conductors.

5. The combination according to claim 1, in which said mobile contact assembly comprises a cruciform dielectric support plate, and said pairs of resilient contact blades are fixed in spaced relation on opposite sides of said cruciform dielectric support plate.

6. The combination according to claim 1, in which a second tubular shell is mounted on said actuator support plate in radially spaced concentric relation within said tubular shell forming the side wall of the envelope, and a third tubular shell is mounted on said actuator support plate within said second tubular shell and about said actuator assembly, said second tubular shell terminating adjacent said fixed contact points to provide a conductive ground plane selectively engageable and disengageable by one of said pairs of resilient contact blades.

7. The combination according to claim 1, in which said actuator assembly includes a shaft slidably disposed on

said actuator support plate and extending into the envelope, an expansible metallic bellows hermetically interposed between said shaft and said actuator support plate, and said mobile contact assembly is mounted on the inner end of said shaft within the envelope.

8. The combination according to claim **1**, in which a first ground plane is mounted within the envelope on one side of said mobile contact assembly and a second ground plane is mounted within the envelope on the opposite side of said mobile contact assembly whereby movement of the mobile contact assembly toward said first ground plane effects engagement of one pair of resilient contact blades therewith and engagement of another pair of resilient contact blades with two selected pairs of fixed contact points whereas movement of the mobile contact assembly toward said second ground plane effects disengagement of said one pair of resilient contact blades from said first ground plane and engagement thereof with two different pairs of fixed contacts, and effects disengagement of said other pair of resilient contact blades from said two first mentioned pairs of fixed contacts and engagement thereof with said second ground plane.

9. The combination according to claim **1**, in which said fixed contact points comprise circumferentially arranged radially inwardly extending integral terminations of said plurality of spaced conductors.

10. The combination according to claim **1**, in which shield means are provided supported on the envelope and interposed between the resilient contact blades of each pair thereof whereby one resilient contact blade of each pair of such blades is shielded against inductive capacitance from the other resilient contact blade of the same pair.

11. The combination according to claim **2**, in which said ground shell mounted on said fixed-contact support plate includes a tubular portion brazed at one end to the support plate and terminating at its other end in an apertured ground plate, the configuration of the aperture being such that the portion of the ground plate which remains cooperates with said resilient contact blades to maintain substantially constant impedance transmission through the relay.

12. The combination according to claim **3**, in which said ground plate is centrally apertured, a portion of said actuator assembly extends through said aperture, and the configuration of the aperture is such that the portion of the ground plate which remains cooperates with said resilient contact blades to maintain substantially constant impedance transmission through the relay.

13. The combination according to claim **3**, in which said ground plate is centrally apertured, and a plurality of circumferentially spaced radially extending shield plates are mounted on said ground plate and extend through said aperture past said resilient contact blades in a manner to shield one resilient contact blade of a pair of such blades against inductive capacitance from the other resilient contact blade of the same pair.

14. In a coaxial cross-point relay, a mobile contact assembly comprising a cruciform dielectric support member having at least two pairs of arms with the arms of one pair extending substantially perpendicular to the arms of the other pair, and a resilient contact blade mounted on each arm of each pair of arms and extending substantially perpendicular to the long dimension of the arm on which it is mounted.

15. The combination according to claim **14**, in which the two blades mounted on each pair of arms constitute a pair of resilient contact blades, and said pairs of resilient contact blades are mounted on opposite surfaces of said cruciform dielectric support member.

16. The combination according to claim **14**, in which a plurality of fixed contact points are provided operatively associated with said mobile contact assembly, opposite ends of each of said resilient contact blades being arranged so as to make or break a circuit through a pair of said fixed contact points.

17. The combination according to claim **16**, in which four such fixed contact points are provided and said resilient contact blades are mounted on said cruciform dielectric support member so that movement of the cruciform dielectric support member in one direction with respect to said fixed contact points effects engagement of one pair of said resilient contact blades with two pairs of said fixed contact points, and movement of the cruciform dielectric support member in the opposite direction effects disengagement of said one pair of resilient contact blades from said first mentioned two pairs of fixed contact points and effects engagament of another pair of said resilient contact blades with two different pairs of fixed contact points.

18. In a coaxial relay including an evacuated envelope having a metallic end wall, a plurality of dielectric bushings extending hermetically through said end wall and bonded thereto, a conductive center conductor extending through each said bushing and bonded thereto, each said conductive center conductor terminating within the envelope in a fixed contact point, a tubular conductive ground shell coaxially associated with each center conductor outside the envelope and engaging said end wall, and a cover plate detachably secured to said end wall and clamping said tubular conductive ground shell between said end wall and said cover plate.

19. The combination according to claim **18**, in which a coaxial connector is secured on said cover plate in continuation of said center conductor and tubular conductive ground shell to connect said fixed contact points with a coaxial transmission line outside the envelope.

References Cited

UNITED STATES PATENTS

2,841,670	7/1958	Peter	200—104
2,997,669	8/1961	Charles	200—153 X
3,131,268	4/1964	Orner	200—153 X

FOREIGN PATENTS

1,075,191	11/1960	Germany.

ROBERT K. SCHAEFER, *Primary Examiner.*

H. HOHAUSER, *Assistant Examiner.*