Nov. 4, 1958 C. W. CONCELMAN 2,859,311

ELECTRICAL SWITCH

Original Filed Nov. 16, 1953 2 Sheets-Sheet 1

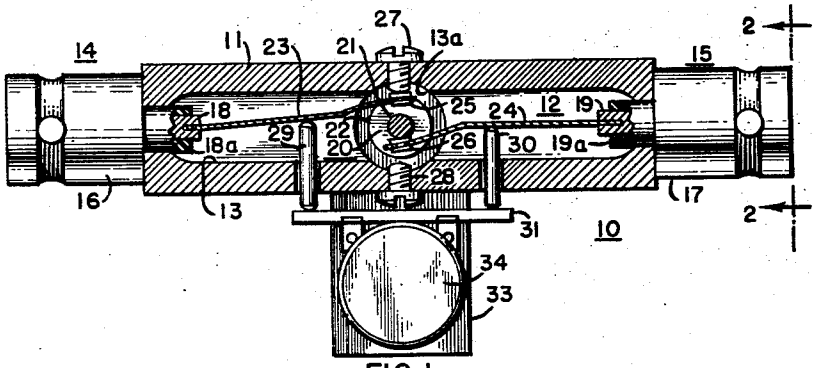

FIG. 1

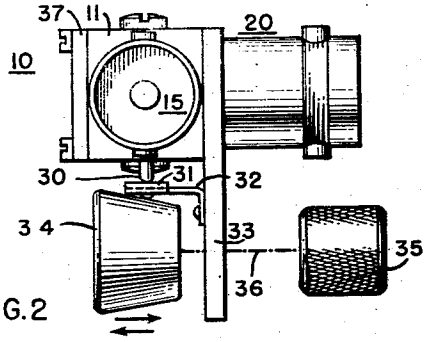

FIG. 2

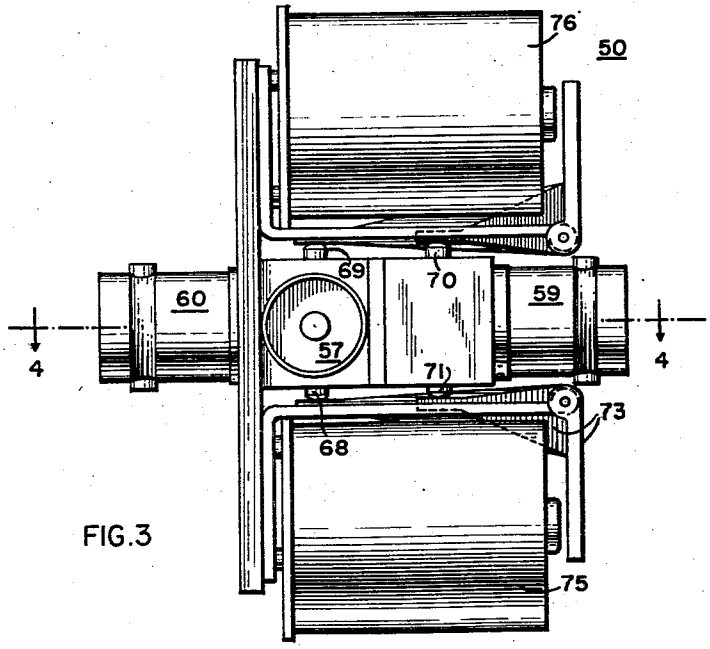

FIG. 3

Nov. 4, 1958 C. W. CONCELMAN 2,859,311

ELECTRICAL SWITCH

Original Filed Nov. 16, 1953 2 Sheets-Sheet 2

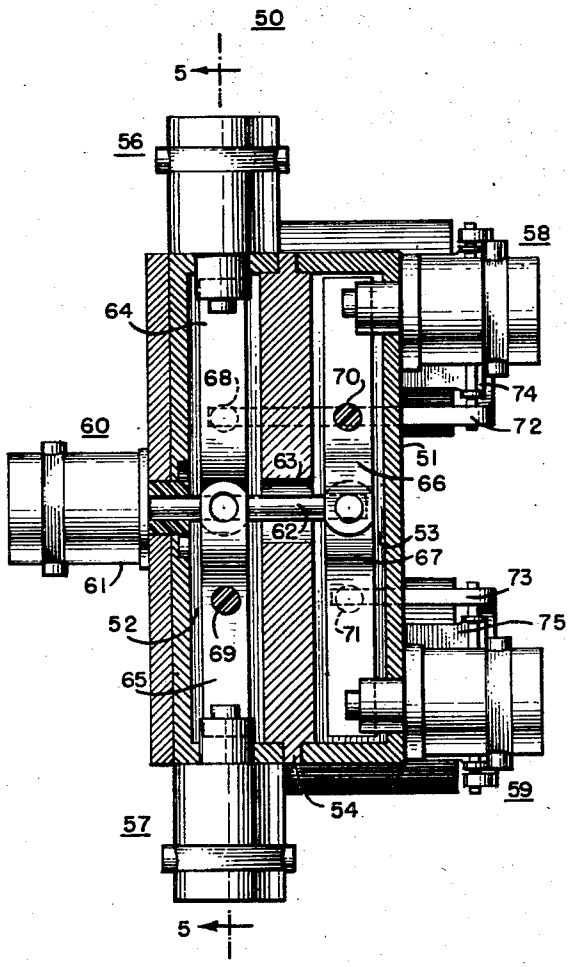

FIG. 4

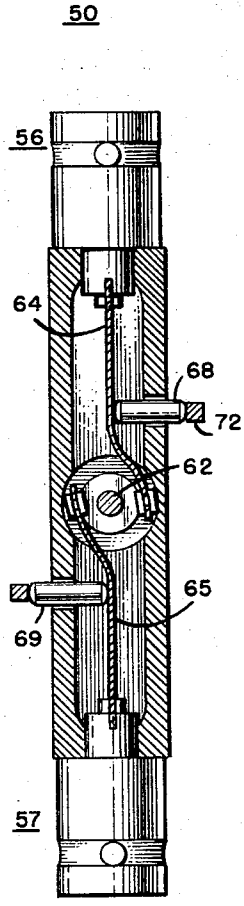

FIG. 5

United States Patent Office 2,859,311 Patented Nov. 4, 1958

2,859,311

ELECTRICAL SWITCH

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Continuation of application Serial No. 392,237, November 16, 1953. This application October 31, 1955, Serial No. 543,785

4 Claims. (Cl. 200—153)

General

This invention relates to electrical switches of the type which selectively connects a first high-frequency wave-signal coaxial transmission line to any of a plurality of such lines.

This application is a continuation-in-whole of applicant's application Serial No. 392,237, filed November 16, 1953, entitled "Electrical Switch."

One prior type of electrical switch for selectively interconnecting coaxial transmission lines utilizes a single relay-actuated spring blade pivotally mounted at one end thereof which is fixedly and conductively attached to the inner conductor of a first transmission line. The other end of the switch arm is displaceable between closely spaced inner conductors of a pair of transmission lines for selectively connecting the individual inner conductors thereof to the inner conductor of the first transmission line. While a switch of this type has desirable characteristics, it has the limitation in certain applications that an unterminated inner conductor extends into the high-frequency energy field and, thus, picks up so-called "cross-talk" signal energy. Moreover, the voltage standing-wave ratio developed by this type of switch may be undesirably high for some applications. Various rotary switches have also been proposed, but in general these may be more expensive to manufacture than is desirable for some applications.

It is an object of the present invention, therefore, to provide a new and improved electrical switch of the type described which avoids one or more of the above-mentioned limitations of prior switches of this type.

It is another object of the invention to provide a new and improved electrical switch of simple and inexpensive construction for selectively connecting a first high-frequency wave-signal coaxial transmission line to any of a plurality of such lines.

It is another object of the invention to provide a new and improved electrical switch of the type described adapted for use in the high-frequency range and which may be readily constructed largely by screw-machine operations.

It is another object of the invention to provide a new and improved electrical switch of the type described which is of simple construction adapted for use in the high-frequency range and which results in reduced cross talk.

In accordance with a particular form of the invention, an electrical switch for selectively connecting a first high-frequency wave-signal coaxial transmission line to any of a plurality of such lines comprises a support having a chamber defined by conductive walls. The switch includes a first coaxial connector for connection to the first transmission line and having an outer conductor conductively connected to the chamber walls and having an inner conductor extending into the chamber. The switch also includes a plurality of coaxial connectors for individual connection to the plurality of transmission lines having outer conductors conductively connected to the chamber walls and having inner conductors. The switch also includes a plurality of movable conductive switch arms

individually conductively connected to the inner conductors of the plurality of connectors and extending within the chamber radially to the inner conductor of the first connector and the axes of the plurality of switch arms being substantially along a common surface substantially perpendicular to the inner conductor of the first connector for selectively conductively connecting the individual inner conductors of the plurality of connectors to the inner conductor of the first connector or to the chamber walls. The switch also includes actuating means for selectively operating the switch arms.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Referring to the drawings:

Fig. 1 is an elevational view, partly in section, of an electrical switch constructed in accordance with a particular form of the invention;

Fig. 2 is an end elevational view of the switch as seen along the line 2—2 of Fig. 1;

Fig. 3 is an elevational view of a modified electrical switch constructed in accordance with the invention;

Fig. 4 is a sectional view of the Fig. 3 switch as seen along the line 4—4 of Fig. 3, and

Fig. 5 is a sectional view of the Fig. 3 switch as seen along the line 5—5 of Fig. 4.

Description of Fig. 1 electrical switch

Referring now more particularly to Fig. 1, there is represented an elevational view, partly in section, of an electrical switch **10** constructed in accordance with the invention for selectively connecting a first high-frequency wave-signal coaxial transmission line to any of a plurality of such lines. The switch **10** includes a support **11** having a chamber **12** which may, for example, be of substanitally uniform, square cross section and preferably is substantially less than one-half wave length long over the operating frequency range of the switch **10**. The chamber **12** is defined by conductive walls including wall **13**, as shown in the drawings. The support **11** may be constructed of any suitable material such as brass which may then be silver plated.

A plurality of coaxial connectors are electrically coupled to chamber **12**. These connectors provide individual connection to transmission lines and having outer conductors conductively connected to the chamber walls and inner conductors which preferably extend into the chamber. More particularly, a pair of like cylindrical connectors **14** and **15** of predetermined diameter are, for example, disposed along a predetermined longitudinal axis of the chamber and have outer conductors **16** and **17**, respectively, conductively connected to and effectively tangential to the chamber walls at opposite ends of the chamber **12**. By "effectively tangential" is meant that the outer cross-sectional dimensions of the chamber **12** preferably are approximately equal to the inner diameter of the outer conductors of the connectors **14** and **15**.

Inner conductors **18** and **19** of the connectors **14** and **15** preferably are spaced from the respective outer conductors thereof by suitable bodies of dielectric material **18***a* and **19***a* extending into the chamber **12** and fixedly disposed within the outer conductors **16** and **17**. The connectors **14** and **15** may be of any suitable type and may, for example, comprise connectors of the type described and claimed in Patent 2,540,012—Salati, entitled "Electrical Connector," granted January 30, 1951.

As may be seen more clearly in Fig. 2, a coaxial connector **20** is disposed along a predetermined normal transverse axis of the chamber **12** which has a longitudinal axis extending into the support **11** along the axis of the

connector **15**. Referring again to Fig. 1, the connector **20** preferably is disposed approximately midway between the pair of connectors **14** and **15** and has an inner conductor **21** which preferably extends into the chamber **12** and is supported within the connector by a body of suitable dielectric material **22** fixedly disposed in a stepped bore **13***a* in the support **11**.

A pair of movable conductive switch arms **23** and **24**, preferably of resilient material, such as beryllium copper, are individually conductively connected and secured to the inner conductors **18** and **19** of the connectors **14** and **15**, respectively, by any suitable means such as soldering. The arms **23** and **24** preferably are seated in suitable slots in the inner conductors **18**, **19** and dielectric spacers **18***a*, **19***a*, respectively, to provide a rigid mechanical support for the arms. The arms **23** and **24** preferably extend within the chamber to the inner conductor **21** of the connector **20** on opposite sides thereof for selectively conductively connecting the individual inner conductors **18** and **19** of the connectors **14** and **15** to the inner conductor **21** of the connector **20** or to the chamber wall **13**. Suitable contact points **25** and **26** are attached to the ends of the switch arms **23** and **24**, respectively, for effecting the desired contact between the respective switch arms and the inner conductor **21** or the chamber wall.

As will be more fully explained hereinafter, the arms **23** and **24** are shown under stress with the arm **24** conductively connected to the inner conductor **21** of the connector **20** and the other arm **23** preferably conductively connected to an adjustable conductive contact screw **27** in the support **11** for effecting a conductive connection to the chamber wall **13**. The arm **24** preferably is conductively connected in the absence of stress thereon to an adjustable conductive contact screw **28** in the support **11** and the other arm **23** preferably is conductively connected in the absence of stress thereon to the inner conductor **21** of the connector **20**.

The switch **10** also includes actuating means for selectively effecting conductive connection of one of the arms **23**, **24** to the inner conductor **21** of the connector **20** or to the chamber wall **13** and the other arm to the chamber wall **13** or to the inner conductor **21** of the connector **20**, respectively. The actuating means comprises, for example, a pair of cylindrical dielectric members **29** and **30** extending through apertures in the wall **13** into the chamber **12** and slidably disposed normal to the arms **23** and **24**, respectively, for deforming the arms in one position thereof, shown in the drawings, selectively to effect conductive connection of the arm **24** under stress to the inner conductor **21** of the connector **20** and the other arm **23** under stress to the chamber wall **13**.

There preferably is also provided control means comprising an elongated cam-operated spring-mounted member **31** for simultaneously displacing the dielectric members **29** and **30** to effect the switching operation. As represented in Fig. 2, the member **31** is attached by means of a spring **32** to a mounting bracket **33** for the switch **10**. A slidably displaceable cam **34**, as indicated by the arrows, is mounted on the bracket **33** and operatively connected to a push-pull switch button **35**, as indicated by a broken line **36**.

From the foregoing description, it will be seen that the various apertures in the support **11** may be formed quickly and conveniently by inexpensive screw-machining operations. The outer conductors of the connectors **14**, **15**, and **20** may be made in a similar manner and the inner conductors thereof may then be assembled and held in a spaced coaxial relation with the respective outer conductors by insulators. The switch arms **23** and **24** may be fabricated by simple stamping operations. After the switch is assembled, a suitable cover **37**, represented in Fig. 2, may be utilized to complete the switch housing. Thus, the manufacture of the switch **10** lends itself to mass-production techniques and the cost thereof is relatively low.

Operation of Fig. 1 electrical switch

Referring to Fig. 2, when the switch button **35** is in the position shown in the drawings, the cam **34** supports the member **31** in the position shown which, in turn, maintains the dielectric actuating members **29** and **30** in the position represented in Fig. 1. In this operating condition, the inner conductor **19** of the connector **15**, which may, for example, serve as an output connector, is connected by the switch arm **24** to the inner conductor **21** of the connector **20** which may, for example, supply input-signal energy to the switch. The inner conductor **18** of the other connector **14**, which may, for example, also be an output connector, is connected to the chamber wall **13** through the screw **27** which may be adjusted for desired contact pressure. The switch arms **23** and **24** effect the respective connections just described under stress exerted thereon by the dielectric members **29** and **30**, respectively.

When the switch button **35** of Fig. 2 is pushed toward the mounting bracket **33**, cam **34** moves into a position which allows the member **31** to spring away from the support **11** as a result of the resiliency of the spring **32**. The resilient switch arms **23** and **24** then spring into contact with the inner conductor **21** and the screw **28**, respectively, and displace the dielectric members **29** and **30** accordingly.

Since there is provided a conductive connection between the chamber wall **13** and the inner conductor of the connector **14** or **15** which is disconnected from the inner conductor **21** of the connector **20**, the energy pickup resulting from capacitive coupling of the disconnected connector is substantially reduced. This results in reduced cross talk between the input connector **20** and the output connector **14** or **15** disconnected therefrom.

It is well known that the characteristic impedance of a high-frequency wave-signal coaxial transmission line is a function of the ratio of the inner diameter of the outer conductor of the transmission line and the outer diameter of the inner conductor thereof. Similar considerations apply to the characteristic impedance of the transmission line effectively formed by the conductive walls of the chamber **12** and the switch arm **23** or **24**. Accordingly, the cross-sectional dimensions of the chamber may be approximately equal to the diameter of the outer conductors of the connectors **14**, **15**, and **20**. The dimensions of the switch arms **23** and **24** may then be selected approximately to provide a desired characteristic impedance for the transmission line effectively formed by the chamber walls and the switch arm **23** or **24**.

By proportioning the length of each half of the chamber **12** to be substantially less than one-quarter wave length over the operating range of the switch **10**, impedance discontinuities within the effective transmission line formed by the chamber **12** and switch arms **23**, **24** can be conveniently proportioned approximately to cancel each other over the operating range. For example, the increase of capacity introduced into the transmission line by the extension of the dielectric spacer **18***a* into the chamber **12** may be approximately canceled by the reduction of capacity present in the region surrounding the inner conductor **21** due to recesses in the chamber walls provided by bore **13***a*. Above the normal operating range of the switch **10**, as the electrical spacing between the above-mentioned discontinuities approaches one-quarter wave length, the discontinuities effectively add rather than cancel because of the impedance transformation effected by a one-quarter wavelength transmission line.

The connectors **14**, **15**, and **20** are effective to provide an approximate impedance match between the transmission lines attached thereto and the transmission line formed by the chamber **12** and the switch arm **23** or **24** and, thus, an approximate impedance match may be

provided between the transmission line connected to the connector **20** and the transmission line connected to either of the connectors **14** and **15**. In this manner, a relatively low voltage standing-wave ratio may result for the switch **10**.

While applicant does not wish to be limited to any particular dimensions, the following approximate dimensions have been employed in a switch constructed in accordance with the invention for use at signal frequencies in the range of 100 to 1000 megacycles:

Length of support **11**_____inches__	2
Width and height of chamber **12**_____do____	¼
Length of switch arms **23, 24**_____do____	¾
Width of switch arms **23, 24**_____do____	.200
Thickness of switch arms **23, 24**_____do____	.008
Spacing between conductor **21** and dielectric members **29, 30**_____inches__	⅜
Extension of conductor **21** into chamber **12** inches__	11/64
Diameter of conductor **21**_____do____	.084
Nominal characteristic impedance of effective transmission line of chamber **12** and switch arms **23, 24**_____ohms__	50

Description of Fig. 3 electrical switch

Referring now to Fig. 3, there is represented an elevational view of a modified electrical switch **50** constructed in accordance with the invention and generally similar to the switch represented in Figs. 1 and 2. As represented in Fig. 4, which is a sectional view of the switch **50** taken along the line **4—4** of Fig. 3, the switch **50** includes a support **51** preferably having a pair of elongated, substantially parallel and longitudinally aligned chambers **52, 53** defined by the conductive walls of the support **51** and a suitable conductive member **54** which separates the chambers within the switch **50**.

Two pairs of coaxial connectors **56, 57** and **58, 59** which may, for example, be output connectors, preferably have outer conductors conductively connected to the walls of the individual chambers adjacent the ends thereof. A coaxial connector **60** serving, for example, as an input connector preferably has an outer conductor **61** conductively connected to the walls of one of the chambers approximately at the mid-point thereof and has an inner conductor **62** extending into both of the chambers **52** and **53** through a suitable bore **63** in the member **54**.

Two pairs of movable conductive switch arms, preferably comprising resilient leaf springs **64, 65** and **66, 67**, are conductively connected to the inner conductors of the corresponding connectors **56, 57** and **58, 59**, respectively, and preferably are conductively connected in the absence of stress thereon to the chamber walls, as represented in Fig. 5, which is a sectional view of the switch **50** taken along the line **5—5** of Fig. 4.

Two pairs of elongated dielectric actuating members **68, 69** and **70, 71** preferably extend through the chamber walls into the individual chambers and may, for example, be individually slidably disposed approximately normal to the arms **64, 65** and **66, 67**, respectively, for deforming the arms selectively to effect conductive connection of one of the arms under stress to the inner conductor **62** of the connector **60** and the other arms to the chamber walls. There preferably is also provided control means for successively displacing the dielectric members to effect the switching operation. This control means comprises, for example, arms **72** and **73**, represented in Fig. 4, responsive to energization of solenoid relays **74** and **75**, respectively, for displacing the dielectric actuating members **68** and **71**, respectively. Similar solenoid relays, such as the relay **76** of Fig. 3 and another relay (not shown), may be provided to control the displacement of the dielectric members **69** and **70**.

Operation of Fig. 3 electrical switch

The operation of the switch **50**, represented in Figs. 3, 4, and 5, may be best understood by referring to Figs. 4 and 5. When the solenoid relays individually controlling the switching operation are de-energized, the corresponding switch elements, such as **64** and **65**, are conductively connected to the chamber walls in their normal positions, as represented in Fig. 5. When one of the relays, such as the relay **74** of Fig. 4, is energized, the relay arm **72** exerts a force which displaces the dielectric member **68**, causing the switch arm **64** to contact the inner conductor **62** of the connector **60**. In this operating condition, the output connector **56** is actively connected to the input connector **60** while the remaining connectors have inner conductors which are conductively connected to the chamber walls and, thus, are effectively disconnected from the input connector.

By means of a suitable electrical switch, not shown, which controls the energization of the solenoid relays, any selected output connector may be connected to the input connector **60** while the remaining connectors are effectively disconnected therefrom. It will also be understood that any suitable number of chambers and output connectors may be aligned with the chambers **52** and **53** to form, for example, a five- or six-position switch. These chambers may individually be proportioned in a manner similar to the chamber **12** of the Fig. 1 switch.

From the foregoing description, it will be apparent that a switch constructed in accordance with the invention has the advantage of being simple in construction and inexpensive to manufacture. The switch has the additional advantage of providing reduced undesired cross talk between input and output connectors thereof. The switch also provides satisfactory standing-wave ratios in, for example, the 100 to 1000 megacycle range.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An electrical switch for conductively connecting a first high-frequency wave-signal coaxial transmission line to any one of a plurality of such lines comprising, a switch support having an internal and substantially hollow chamber extending longitudinally between interior conductive end walls, said chamber having a substantially uniform cross-section defined by confronting pairs of parallel and interior conductive walls, a first coaxial connector electrically coupled to said chamber intermediate the end walls thereof and adapted for connection with the first of said transmission lines, said connector having an outer conductor conductively connected to said chamber walls and an inner conductor extending into said chamber and terminating therein wherein the axis of said connector in the region where it effects electrical coupling to said chamber is substantially perpendicular to the longitudinal dimension of said chamber, a coaxial connector electrically coupled to said chamber on each side of said first connector and defining a plurality of connectors for individual connection to respective ones of said plurality of transmission lines, said plurality of connectors each having an outer conductor conductively connected to said chamber walls and an inner conductor terminating in said chamber, a plurality of movable conductive switch arms having a substantially uniform cross-section defined by opposed pairs of parallel surfaces, said arms extending substantially longitudinal-wise in said chamber for movement from one to another of two positions wherein said first connector is alternately connected to and disconnected from respective ones of said plurality of connectors, each arm having one end conductively con-

nected to and supported from a respective one of the inner conductors of said plurality and having a free end adapted for conductive connection with the inner conductor of said first connector, wherein each arm and the coextending chamber walls surrounding same serve as a section of coaxial line coupling said first connector with a respective one of the plurality of connectors when the correlated arm is positioned to effect conductive connection with the inner conductor of said first connector.

2. An electrical switch for conductively connecting a first high-frequency wave-signal coaxial transmission line to any one of a plurality of such lines comprising, a switch support having an internal and substantially hollow chamber extending longitudinally between interior conductive end walls, said chamber having a substantially uniform cross-section defined by confronting pairs of parallel and interior conductive walls, a first coaxial connector electrically coupled to said chamber intermediate the end walls thereof and adapted for connection with the first of said transmission lines, said connector having an outer conductor conductively connected to said chamber walls and an inner conductor extending into said chamber and terminating therein wherein the axis of said connector in the region where it effects electrical coupling to said chamber is substantially perpendicular to the longitudinal dimension of said chamber, a coaxial connector electrically coupled to said chamber on each side of said first connector and defining a plurality of connectors for individual connection to respective ones of said plurality of transmission lines, said plurality of connectors each having an outer conductor conductively connected to said chamber walls and an inner conductor terminating in said chamber, a plurality of movable conductive switch arms having a substantially uniform cross-section defined by opposed pairs of parallel surfaces, said arms extending substantially longitudinal-wise in said chamber for movement from one to another of two positions wherein said first connector is alternately connected to and disconnected from respective ones of said plurality of connectors, each arm having one end conductively connected to and supported from a respective one of the inner conductors of said plurality and having a free end adapted for conductive connection with the inner conductor of said first connector, movement of an arm to a first of its positions causes the free end thereof to contact conductively with a chamber wall juxtaposed the first inner conductor, movement of an arm to the second of its positions causes the free end thereof to contact conductively with the inner conductor of said first connector wherein such arm and the coextending chamber walls surrounding same serve as a section of coaxial line coupling said first connector with the correlated connector of said plurality.

3. Apparatus ase defined in claim 2, wherein the cross-

section of said chamber is substantially square shaped and wherein the dimensions thereof are each approximately equal to the dimension of the inner diameter of the outer conductors of said plurality of connectors.

4. An electrical switch for selectively connecting a first high-frequency wave-signal transmission line to any one of a plurality of such lines comprising, a switch support having a plurality of adjacent internal and substantially hollow chambers extending longitudinally between interior conductive end walls, each chamber having a substantially uniform cross-section defined by confronting pairs of parallel and interior conductive walls, a first coaxial connector for connection to said first transmission line and having an outer conductor conductively connected to said chamber walls, said connector also having an inner conductor extending through a first of said chambers and extending into and terminating within a second of said chambers, the axial dimension of said inner conductor being substantially perpendicular to the longitudinal dimension of said first and second chambers and being disposed intermediate the end walls thereof, pairs of coaxial connectors for individual connection to said plurality of transmission lines and having outer conductors conductively connected to said chamber walls, the inner conductors of each pair of connectors extending into respective ones of said chambers on opposite sides of the inner conductor of the first connector, pairs of movable conductive switch arms having a substantially uniform cross-section defined by opposed pairs of parallel surfaces, one pair of each of said arms extending substantially longitudinal-wise in a respective chamber for movement from one to another of two positions wherein said first connector is alternately connected to and disconnected from respective ones of said plurality of connectors, each arm having one end conductively connected to and supported from a respective one of the inner conducotrs of said plurality and having a free end adapted for conductive connection with the inner conductor of said first connector, and means for operating said switch arms wherein movement of an arm to a first of its positions causes the free end of said arm to contact conductively with the chamber wall juxtaposed the first inner conductor, and movement of an arm to the second of its positions causes its free end to make contact with said first inner conductor wherein such arm and the coextending chamber wall surrounding same serve as a section of coaxial line coupling said first connector with the correlated connector of said plurality.

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