# United States Patent

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[54] **MIDSPAN ELECTRICAL CONDUCTOR SPACER**
**14 Claims, 6 Drawing Figs.**


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[51] **Int. Cl.** ..... **H01b 17/16,** H01b 17/32, H02g 7/12
[50] **Field of Search** ..... 174/42, 140.1, 146, 148, 149, 150, 169, 176, 177, 178, 179, 181, 182, 186, 189, 196, 209



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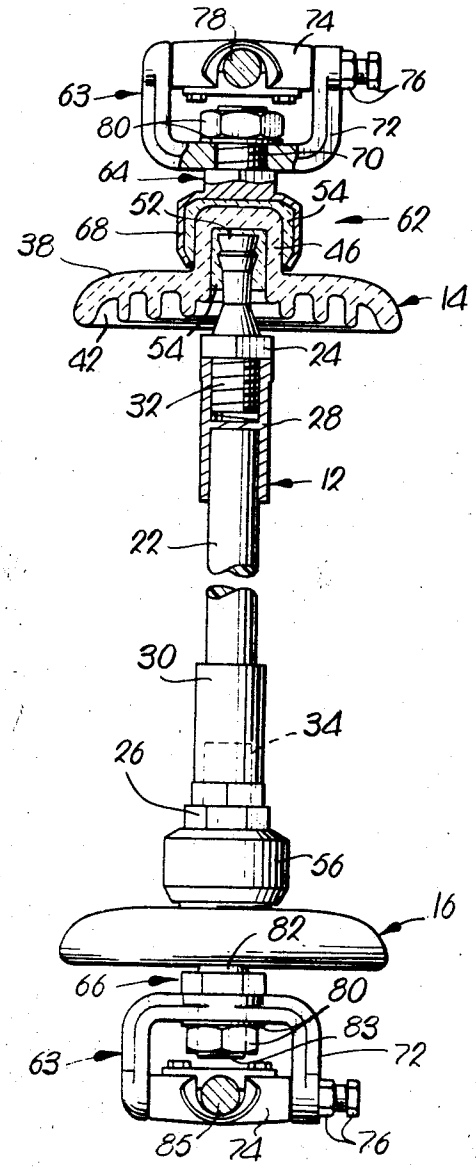
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**ABSTRACT:** A midspan spacer for maintaining adjacent high voltage conductors in spaced relationship includes an elongated, relatively lightweight spacer unit of insulating material, a conductor clamp at either end of the unit, and an insulator having high flash over-resistance characteristics adjacent each of the clamps. The spacer unit is characterized by a high compressive strength in relationship to its weight to withstand the substantial forces exerted thereon when the conductors tend to move relative to each other. All of the components of the spacer are held together by a bonding agent, and means is provided to load each of the bonds in compression, thereby utilizing the full load-bearing capacity of the bonding agent.

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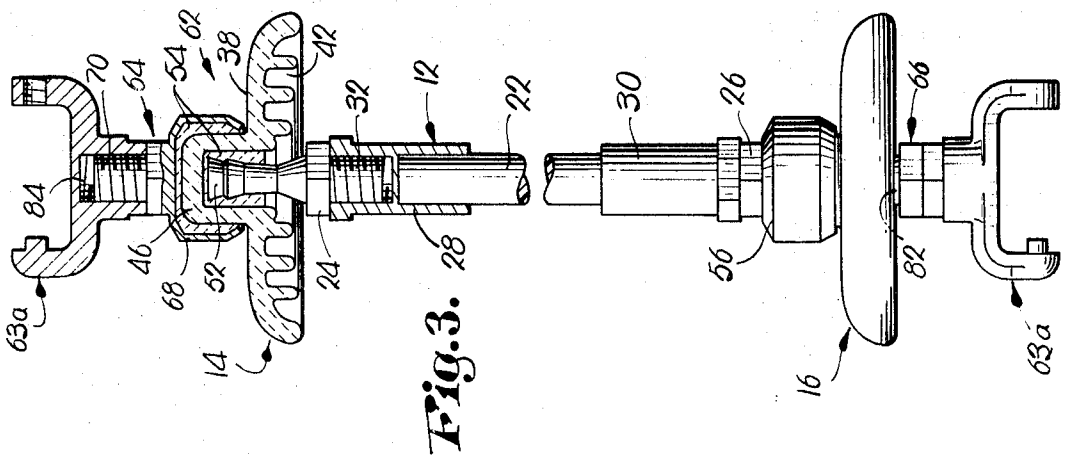


Fig. 3.

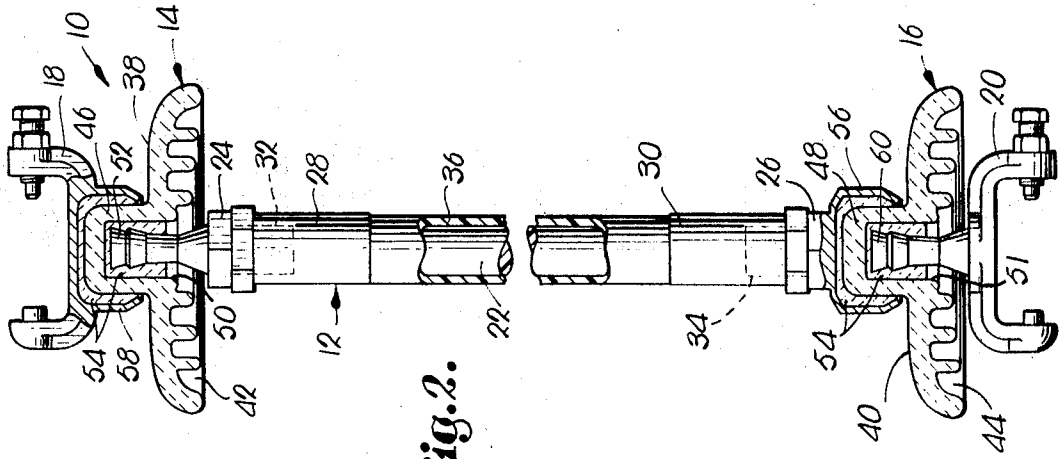


Fig. 2.

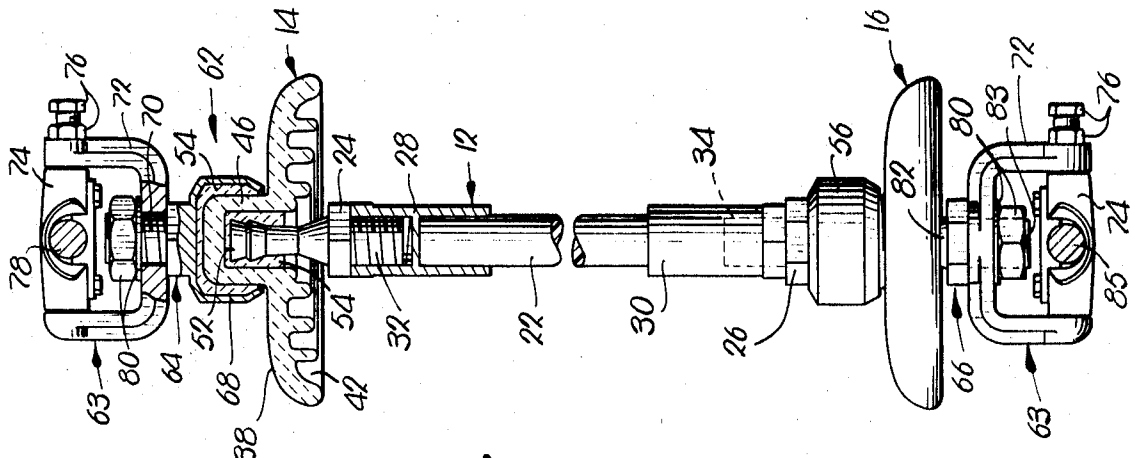


Fig. 1.

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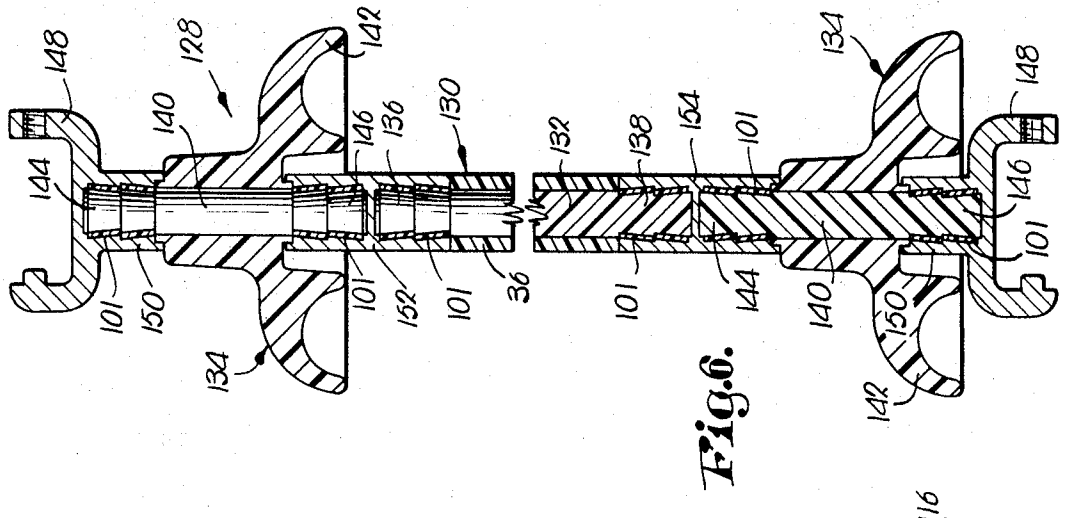



Fig.6.

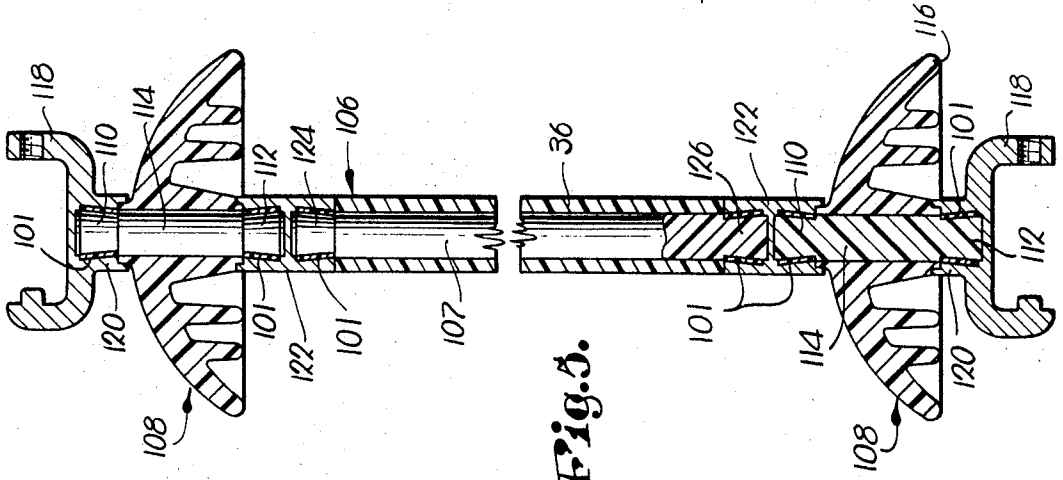



Fig.5.

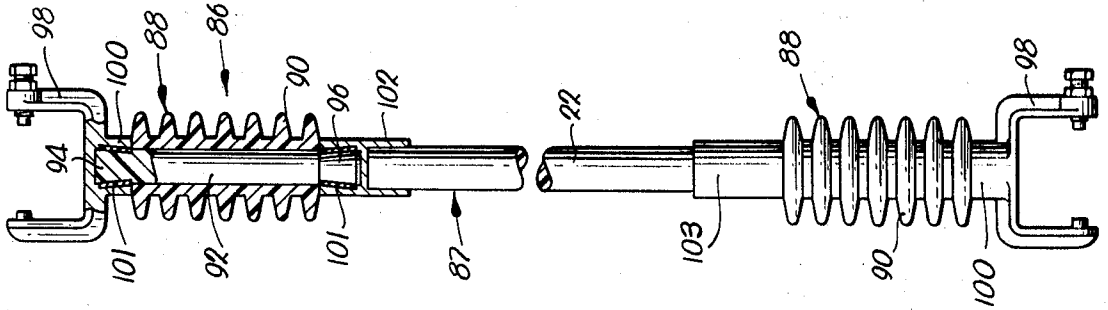



Fig.4.

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# MIDSPAN ELECTRICAL CONDUCTOR SPACER

This invention relates to high voltage power transmission equipment and, more particularly, to a spacer for maintaining adjacent high voltage conductors of a multiple phase transmission line in spaced relationship at midspan.

Overhead transmission lines are usually required to span long distances from a generating station to a substation. Although the degree of drape of such lines varies according to the standards of a particular power company and the terrain over which it is erected, this drape is carefully calculated in each case.

Wind-induced vibration is a persistent operating hazard of overhead transmission lines, and the most dangerous category of wind-induced line movements has traditionally been designated galloping. Although galloping conductors are not encountered during normal weather and atmospheric conditions, the buildup of ice on the lee side of a conductor can cause a crude airfoil which, in conjunction with the torsional response of the conductor, can produce a varied assortment of violent wave motions. The introduction of bundle conductor systems in recent years has caused renewed interested in attempting to control galloping conductors, since bundle conductor systems have been observed vibrating in large amplitudes when no ice was present.

Attempts to provide a spacer for spanning the substantial distance between different phase conductors of a multiple phase transmission line has met with little success. The problem which has heretofore not been overcome is meeting the rather substantial insulator requirements necessary to prevent flashover between phases, while keeping the spacer sufficiently lightweight so as not to interfere with the drape of the lines. The fact that a midspan spacer must be relatively lightweight has also prevented the construction of a unit of sufficient strength to withstand the substantial forces exerted thereon when adjacent conductors tend to move relative to one another. It has also been found that it is desirable to construct a midspan spacer in a rigid assembly, avoiding any moving parts. This is necessary to reduce arcing and resulting radio interference which can occur, especially when moving parts become contaminated. More importantly, numerous investigations of galloping conductors have shown that torsional rotation of a conductor is an essential element of galloping movement. Only with a completely rigid structure can such torsional forces be completely eliminated.

It is, therefore, an object of the present invention to provide a spacer for insertion at midspan of a multiple phase high voltage transmission line which, because of its light weight, does not adversely affect the drape of the line.

It is another object of the present invention to provide a spacer for insertion at midspan of a high voltage transmission line which, because of its insulative properties can be placed between different phases of a multiple phase line without danger of flashover between lines.

Still another object of the invention is to provide a high voltage transmission line spacer having sufficient strength to withstand the substantial forces which tend to move adjacent lines relative to each other.

Additionally, an object of the present invention is to provide a midspan spacer as aforesaid wherein a bonding agent is used to interconnect the various components of the spacer, thereby avoiding mechanical connections which would detract from the insulative qualities of the spacer and add to the weight thereof.

An object of this invention is also to provide a midspan spacer as described in foregoing objects wherein a frustoconical fitting loads the bonding agent in compression, thereby utilizing the maximum strength of the bonding agent.

Still another important object of the invention is to provide a midspan spacer which, because of its completely rigid structure, does not result in increased radio interference along a transmission line.



A very important object of this invention is also to provide a midspan spacer which, because of its completely rigid structure, is effective in eliminating the torsional movements which are associated with galloping conductors.

It is also an object of this invention to provide a midspan spacer of rigid construction as described in the foregoing objects wherein the component parts of the spacer can be individually replaced for economical maintenance.

In the drawings:

FIG. 1 is a front elevational view of a midspan spacer with one of the insulators, one of the connecting ferrules and portions of one of the conductor clamps being shown in cross section;

FIG. 2 is a front elevational view of an alternative embodiment of the midspan spacer with the two insulators and portions of the connections and protective jacket around the spacer unit being shown in cross section;

FIG. 3 is a front elevational view of the midspan spacer shown in FIG. 1 illustrating a different form of conductor clamp which may be utilized therewith;

FIG. 4 is a front elevational view of an alternative embodiment of the midspan spacer with one of the insulators and certain other portions being shown in cross section;

FIG. 5 is a front elevational view of still another alternative embodiment of the midspan spacer with the insulators at either end of the spacer unit, the conductor clamps, the protective jacket over the spacer unit, and other portions of the apparatus being shown in cross section; and

FIG. 6 is a front elevational view of yet another alternative embodiment of the midspan spacer with major portions of the same being shown in cross section for purposes of illustration.

Referring initially to the preferred embodiment of the spacer apparatus which is shown in FIG. 2 of the drawings and designated generally by the numeral **10**, the apparatus **10** includes an elongated insulator assembly **12** which has a pair of insulators **14** and **16** secured to opposite ends thereof, and a pair of conductor clamps **18** and **20** adjacent each of the insulators **14** and **16** respectively. The insulator assembly **12** includes an elongated, relatively lightweight spacer unit **22** which is preferably constructed from a fiberglass reinforced resinous material and connecting portions **24** and **26** which connect the insulators **14** and **16** respectively to the spacer unit **22**. Metal ferrules **28** and **30**, each of which has opposed openings therein are secured to the spacer unit **22** by an appropriate bonding agent. Each of the connecting portions **24** and **26** is provided with a threaded stud **32** and **34** respectively which is received within one of the openings of the ferrules **28** and **30** respectively. The spacer unit **22** is provided with a protective jacket **36** of insulating material, such as an epoxy resin, which is disposed in surrounding relationship to the unit **22** and frictionally engages the same over substantially the entire length thereof. If is also to be noted that the jacket **36** abuts the respective ferrules **28** and **30**.

Each of the insulators **14** and **16** comprises an annular body having an uninterrupted curvilinear first surface **38** and **40** respectively, and a second surface **42** and **44** respectively comprised of a plurality of interconnected annular ridges. Each of the insulators **14** and **16**, which is preferably constructed from a material such as porcelain having high flashover resistance characteristics, is configured to present a cap **46** and **48** on the side of its curvilinear surface **38** and **40**, respectively, and a cavity **50** and **51** opposite each of the caps **46** and **48** respectively.

It is to be noted that the insulator **14** is disposed with its cap **46** extending away from the insulator assembly **12**, while the other insulator **16** is disposed with its cap **48** extending toward the assembly **12**. With this arrangement of the insulators **14** and **16**, the connecting portion **24** is configured to present a frustoconical tongue **52** which is disposed within the cavity **50**. A suitable bonding agent **54** is disposed within the cavity **50** and interconnects the insulator **14** with the tongue **52**. The connecting portion **26** is provided with a depending skirt **56** which terminates in a frustoconical lip. The cap **48** is covered

with a layer of the bonding agent **54** and the skirt **56** is disposed in circumscribing relationship to the cap **48** and the bonding agent **54** thereon.

The U-shaped saddle-type conductor clamp **18** is provided with a depending skirt **58** which, like the skirt **56**, terminates in a frustoconical lip and circumscribes the cap **46** with a layer of the bonding agent **54** securing the skirt **58** to the cap **46**. The conductor clamp **20**, which is generally of the same type as the conductor clamp **18**, is provided within the cavity **51**. A layer of the bonding agent **54** is also placed within cavity **51** to join the tongue **60** to the cap **48**.

It is to be understood that portions of the conductor clamps **18** and **20** have been omitted from FIG. **2** for purposes of illustration only, although the omitted portions are shown and described in conjunction with the embodiment of FIGS. **1** and **3**. When the conductor clamps **18** and **20** are secured to two adjacent phases of a multiple phase transmission line with the insulator assembly **12** substantially spanning the normal distance between the conductors, the two phases will be maintained in their normal predetermined spaced relationship even under conditions which would normally produce galloping conductors.

A very desirable feature in the construction of the apparatus **10** is the provision of frustoconical bond-engaging means for each of the bonding layers **54**. It is to be emphasized that a suitable parting agent, for example silicone or petrolatum, is normally placed on the metal component, such as tongue **52** or skirt **58**, with which the bonding layer **54** comes in contact to prevent the latter from adhering to two surfaces. This eliminates the possibility of shear forces acting on the bonding layer and, by virtue of the frustoconical portions, the bonds are loaded in compression when the two conductors tend to move away from each other, thereby utilizing the compression strength of the bonding agent which is normally considerably greater than its tensile strength. It is also important for the spacer unit **22** to be constructed from a material having a high compressive strength in relationship to the weight thereof in order for the unit to withstand the substantial compressive forces which are exerted thereon when two phases tend to move toward each other. The protective jacket **36** which surrounds the spacer **22**, serves as a shield to protect the spacer from atmospheric contaminants which would detract from its insulative properties. If the jacket **36** becomes excessively contaminated, the spacer **22** can be replaced at a relatively small cost. The disposition of the jacket **36** in abutting relationship to the ferrules **28** and **30** also helps to eliminate corona effects at the edges of the ferrules, since these components are usually constructed from a conductive material.

Referring additionally to FIGS. **1** and **3**, an alternative embodiment of the apparatus **10** is designated generally by the numeral **62** and includes an elongated insulator assembly **12** of the type previously described, having a spacer unit **22**, connecting portions **24** and **26** and ferrules **28** and **30** which are assembled together in the same manner as previously described for the preferred embodiment. A pair of conductor clamps **63** in FIG. **1**, and **63***a* in FIG. **3**, are joined to the insulators **14** and **16** respectively by connecting legs **64** and **66** respectively. Each of the connecting legs **64** at one end of each assembly **12** is provided with a depending skirt **68** which terminates in a frustoconical lip as previously described for the skirts **56** and **58**, and an upstanding threaded stud **70** which extends along the longitudinal axis of the spacer unit **22**. A layer of the bonding agent **54** joins the skirt **68** to the cap **46** of the insulator **14**. The conductor clamp **63** presents a U-shaped yoke **72** which pivotally receives a saddle clamp **74** by means of a nut and bolt assembly **76**. The saddle clamp **64**, in turn, holds a conductor cable **78**. The yoke **72** has an opening in its horizontal crossarm which permits the clamps **63** to be positioned over the stud **70** and held in place by a nut and washer assembly **80**. It is to be noted that each connecting leg **66** at the other end of each assembly **12**, in place of a skirt such as **68**, is provided with a tongue **82** (only partially visible in FIG. **1**) of the same configuration as the tongue **60** previously described. The connecting leg **66** is also provided with a threaded stud **83** which receives a clamp **63** in the same manner as connecting leg **64**. A second nut and washer assembly **80** secures the clamp **63** to the connecting leg **66**, and a second saddle clamp **74** receives a second conductor **85** in the same manner as previously described for the conductor **78**.

As illustrated in FIG. **3**, the connecting legs **64** and **66** can also accommodate conductor clamps **63***a*, each of which is provided with a threaded bore **84** thus permitting a clamp **63***a* to be received directly by a threaded stud **70** without the need for auxiliary fastening means such as the nut and washer assembly **80**.

While no protective jacket is shown in FIGS. **1** and **3** surrounding the spacer unit **22**, it is to be understood that a jacket such as **36** could be utilized with the alternative embodiment **62** or a protective coating applied to the unit **22** to increase the life thereof. An appropriate parting agent such as described above in connection with the apparatus **10** is placed on the metal surfaces of the metal surfaces of the apparatus **62** with which the bonding agent **54** comes in contact. It will be appreciated that the alternative embodiment **62** has the same high compressive strength and flashover resistance characteristics as the apparatus **10**, and by using the connecting legs **64** and **66** to join the conductor clamps to the insulators **14** and **16**, a single type of conductor clamp may be utilized at either end of the apparatus.

Referring to FIG. **4** of the drawings wherein a third alternative embodiment of the midspan spacer is designated generally by the numeral **86**, it is seen that the apparatus **86** utilizes an insulator assembly **87** which includes an elongated, relatively lightweight spacer unit **22** of the type previously described, and a pair of insulators **88** at either end of the spacer unit **22** having multiple insulator skirts **90** which are preferably cast from resinous material about a central rod **92**. Each of the insulators **88** has a pair of opposed, frustoconical end portions **94** and **96** which project from the endmost insulator skirts **90**. A pair of conductor clamps **98**, each of which is provided with a depending leg portion **100** having an opening therein is secured to the outwardly projecting end portion **94** by a suitable bonding agent **101**. The other projecting end portions **96**, one of which is visible in FIG. **4**, are each received in ferrules **102** and **103** and secured thereto by a layer of the bonding material **101**. Each of the ferrules **102** and **103** also receives one end of the spacer unit **22**, the latter also being secured by a suitable bonding agent (not shown). An appropriate parting agent is used in connection with the bonding layers for reasons previously discussed.

It will be appreciated that the multiple insulator skirts **90** which are an integral part of the apparatus **86** give the apparatus superior flashover resistance characteristics, thereby making this embodiment particularly useful where atmospheric or electrical conditions warrant increased insulative properties. Production advantages are also inherent in an insulator such as **88** which can be cast from a resinous material.

Referring to FIG. **5** wherein a fourth alternative embodiment **104** is illustrated, the apparatus **104** employs an elongated insulator assembly **106** which includes an elongated spacer unit **107** constructed from the same lightweight insulative material as the spacer unit **22** previously described, and a pair of insulators **108** secured to either end thereof. Each of the insulators **108** is provided with frustoconical end projections **110** and **112** which extend from a central rod **114** around which the insulator skirt **116** is cast preferably from a resinous material. A pair of conductor clamps **118**, each of which has a depending leg portion **120**, are secured to the end projections **110** and **112** respectively by a layer of the bonding agent **101** in the same manner as previously described for the conductor clamps **98**. Each of the other end projections **110** and **112** is disposed within a connecting ferrule **122** and held therein by a layer of the bonding agent **101**. Again, an appropriate parting agent is utilized in connection with the bonding agent **101**. It is to be noted that the spacer unit **107** differs from the spacer

units **22** previously described in that it is provided with frustoconical end projections **124** and **126** which are received by the connecting ferrules **122** and held therein by a layer of the bonding agent **101**. A protective jacket **36** of the type previously described, surrounds the spacer unit **107** and abuts the connecting ferrules **122**.

Referring to FIG. **6** wherein the last alternative embodiment of the invention is shown, the apparatus **128** includes an elongated insulator assembly **130** having an elongated spacer unit **132** constructed from a fiberglass reinforced resinous material and a pair of insulators **134** disposed at either end of the unit **132**. The spacer unit **132** is characterized by double frustoconical end projections **136** and **138**. Similarly, each insulator **134** comprises a central rod **140** around which an insulator skirt **142** is cast, preferably from a resinous material having high flashover resistance characteristics, and the ends of each of the rods **140** extend outwardly from the skirt **142** to present double frustoconical end portions **144** and **146**. A pair of conductor clamps **148**, each having a depending leg portion **150** with an opening therein which defines a double frustoconical socket, receive the outwardly extending frustoconical end portions **144** and **146** respectively of the two insulators **134** and the same are secured thereto by a layer of the bonding agent **101**. The inwardly projecting end portions **144** and **146** of the two insulators **134** are received within a double frustoconical socket of a pair of connecting ferrules **152** and **154** and also secured by the bonding agent **101**. It is to be understood, of course, that an appropriate parting agent is used with the bonding agent **101**, as previously discussed. A second double frustoconical socket in each of the connecting ferrules **152** and **154** receives the double frustoconical end projections **136** and **138** respectively with the bonding agent **101** again completing the connection. A protective jacket **36** of the type previously described surrounds the spacer unit **132** and abuts the connecting ferrules **152** and **154**.

It is to be noted that the spacer units **107** and **132** are distinguishable from the spacer units **22** previously described by their frustoconical end portions which are received within the respective connecting ferrules. This arrangement serves to transfer tensile loads to compression loads on the bonding agent **101** and is particularly advantageous where excessive strains are exerted on the insulator assembly. The spacer unit **132** differs from the unit **107** only in that it is provided with double frustoconical end portions as are the adjoining insulators **134**. This arrangement would normally be used only when extremely high forces tending to move the two conductors held by the spacer away from each other are likely to be encountered. It is to be understood, of course, that in those instances where relatively small forces are encountered tending to move the two conductors held by a spacer away from each other the frustoconical compression fittings shown on any of the foregoing embodiments could be omitted and a noncompression fitting substituted therefor. Furthermore, with any of the embodiments shown and described herein, the spacer units **22**, **107** and **130** can be constructed in varying lengths to accommodate different spacing between conductors of a multiple phase transmission line. While various forms of insulators have been shown in the foregoing embodiments, other forms of insulators could be used without departing from the scope of the invention. For example, an insulator string of any length necessary to provide the required flashover resistance characteristics, could be substituted for any of the insulators shown and described herein.

It will be appreciated that with any of the embodiments shown an described a rigid spacer assembly is presented wherein the component parts can be effectively tightened to minimize radio interference. Such a rigid assembly will preclude torsional movements of the spaced conductors and is, therefore, extremely effective in controlling galloping conductors yet, because of its light weight, does not adversely affect the drape of the lines.

While damage to transmission line hardware is common from such sources as lightning, current surges, and hunters, it is readily apparent that with any of the spacer embodiments shown and described the various component parts can be individually replaced without replacement of the entire spacer assembly.

Having thus described the invention, what I claim as new and desired to be secured by Letters Patent is:

**1**. A midspan spacer for maintaining adjacent high voltage conductors in normal predetermined spaced relationship, said spacer comprising:

a clamp for each conductor;

yoke structure supporting each conductor clamp for pivoting movement thereof only about an axis extending transversely of a respective conductor; and

an elongated insulator assembly rigidly affixed to and maintaining said yoke structures and the conductor clamps carried thereby in spaced relationship, said assembly being of a length to substantially span the normal distance between said conductors and thereby maintain the latter in said predetermined spaced relationship,

said assembly including an elongated, relatively lightweight spacer unit of insulating material and having a high compressive strength in relationship to the weight thereof to prevent flow of current between the conductors held by said clamps and to prevent movement of said conductors toward and away from each other under widely varying loads and operating conditions, and

at least one insulator having high flashover characteristics rigidly interposed between each extremity of the unit and a corresponding yoke structure.

**2**. Apparatus as set forth in claim **1**, including a bonding agent joining said insulators to respective yoke structures; and frustoconical bond-engaging means for loading said agent in compression when said conductors tend to move relative to one another.

**3**. Apparatus as set forth in claim **2**, each of said yoke structures having an elongated opening therein, said bonding agent being disposed within said openings, said bond-engaging means comprising a tongue rigid with each of said insulators disposed within an adjacent opening.

**4**. Apparatus as set forth in claim **2**, wherein each of said insulators is configured to present a cap on one side thereof and a cavity on the other side thereof, one of said insulators being disposed with its cap extending toward said assembly, the other of said insulators being disposed with its cap extending away from said assembly, said bonding agent being disposed within the cavity of said one insulator and around the cap of said other insulator, said bond-engaging means including a leg depending from one of said yoke structures and disposed within the cavity of said one insulator and a skirt depending from the other of said yoke structures and disposed in circumscribing relationship to the cap of said one insulator and the bonding agent thereon.

**5**. Apparatus as set forth in claim **4**, said assembly including a first connecting portion configurated to receive the cap of said one insulator and a second connecting portion configurated to be received within said cavity in the other insulator.

**6**. Apparatus as set forth in claim **5**, including a bonding agent joining said portions to said insulators, each of said portions including frustoconical bond-engaging means for loading said agent in compression when said conductors tend to move relative to one another.

**7**. Apparatus as set forth in claim **6**, said assembly including a pair of connecting ferrules each having opposed openings therein, one of said openings receiving one end of a respective connecting portion; and an elongated insulating rod having its end disposed in the other of said openings.

**8**. Apparatus as set forth in claim **7**, and a jacket of insulating material surrounding said rod and in frictional engagement therewith, said jacket abutting the respective connecting ferrules.

**9**. Apparatus as set forth in claim **1**, said insulator comprising an annular porcelain body having an uninterrupted curvilinear first surface and a second surface comprising a plurality of interconnected annular ridges.

10. A midspan spacer for maintaining adjacent high voltage conductors in normal predetermined spaced relationship, said spacer comprising:

a connecting clamp for each conductor, each of said clamps having a conductor receiving saddle and yoke structure pivotally supporting the saddle for pivoting movement thereof only above an axis extending transversely of a respective conductor, each of said yoke structure having a depending leg portion with an opening therein;

an insulator for each clamp respectively and having relatively high flashover resistance characteristics, each of said insulators having a projecting end portion, said end portion of each insulator being received within a respective opening;

first connecting means rigidly securing said end portion of each insulator to a corresponding yoke structure within a respective opening;

an elongated, relatively lightweight unit of insulating material of a length to substantially span the distance between said conductors, said unit having a relatively high compressive strength in relationship to the weight thereof; and

second connecting means rigidly joining the corresponding ends of said unit to respective insulators for maintaining said conductors in predetermined spaced relationship.

11. Apparatus as set forth in claim 10, wherein said first connecting means comprises a bonding agent within each of said openings and each of said end portions is of a frustoconical configuration to thereby load said bonding agent in compression when said conductors tend to move relative to one another.

12. Apparatus as set forth in claim 10, each of said insulators having a second projecting end portion in opposed relationship to the first mentioned projecting end portion, said second connecting means comprising a pair of connecting ferrules each having opposed openings therein, one of said openings receiving said second projecting end portion of a respective insulator, the other of said openings receiving the respective ends of the insulating unit.

13. Apparatus as set forth in claim 10, wherein each of said insulators comprises an elongated rod of resinous insulating material with a resinous insulating skirt secured to said rod intermediate the ends thereof.

14. Apparatus as set forth in claim 13, wherein a plurality of insulator skirts are disposed in closely spaced relationship intermediate the ends of said rod.