# United States Patent

[11] 3,611,274


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[54] **BREAKAWAY CONNECTOR**
**10 Claims, 7 Drawing Figs.**


[52] **U.S. Cl.** ..... **339/278 M,** 89/1.811, 174/84, 200/64, 339/46, 339/176 M, 339/255 R
[51] **Int. Cl.** ..... **H01r 3/02**
[50] **Field of Search** ..... 339/17, 45, 46, 34, 59, 60, 64, 176, 255, 278; 174/84, 88; 89/1.811; 200/62 T



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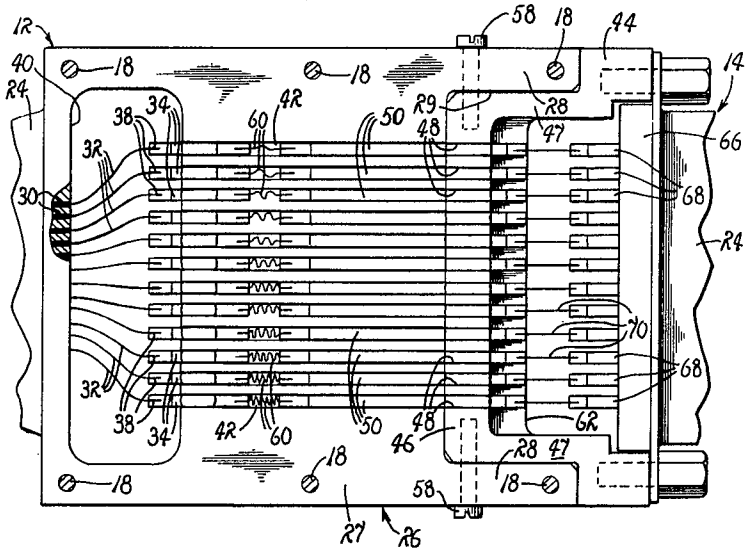
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**ABSTRACT:** A breakaway connector particularly suited for use in connecting cable ends of multiwire cables characterized by a separable pair of juxtaposed connector units, each including a plurality of laterally spaced electrical terminals coupled with adjacent ends of selected circuit leads, a feature of the connector being an inclusion of a plurality of flexible connector leads, each being of a unique length and serving to interconnect adjacent terminals of the mated units in a manner such that as the pair of units is separated the flexible leads sequentially are tensioned for developing a stress sufficient to achieve a rupture thereof, whereby a sequential separation of the plurality of leads is achievable through an application of a tensioning force having a magnitude sufficient for rupturing a single lead as separation of the connector units occurs.

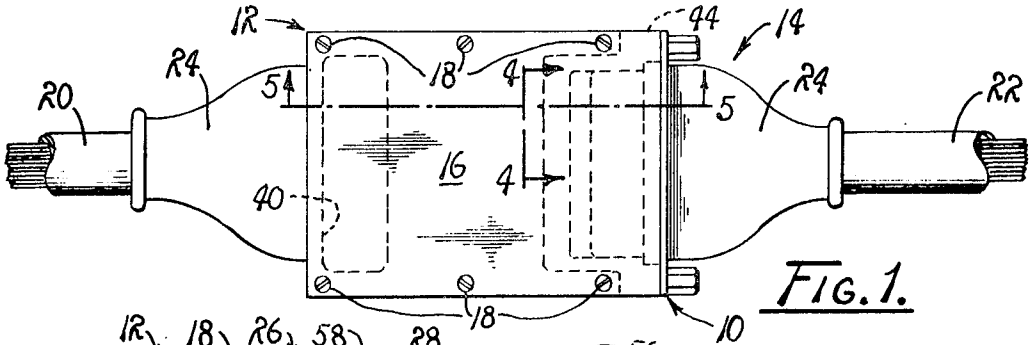



FIG. 1.

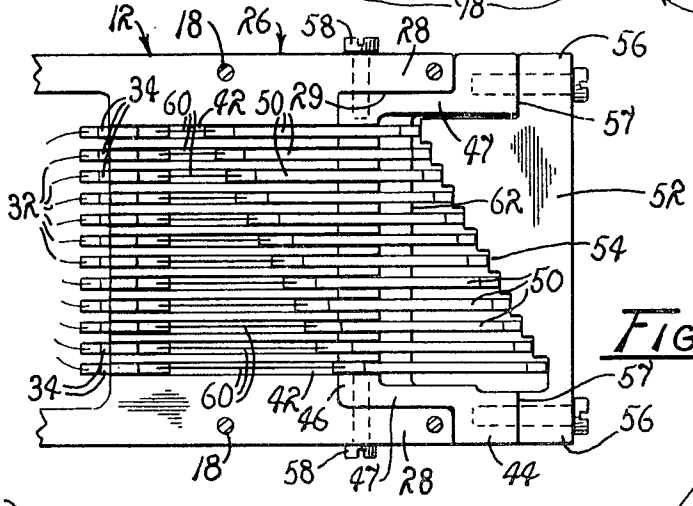



FIG. 2.

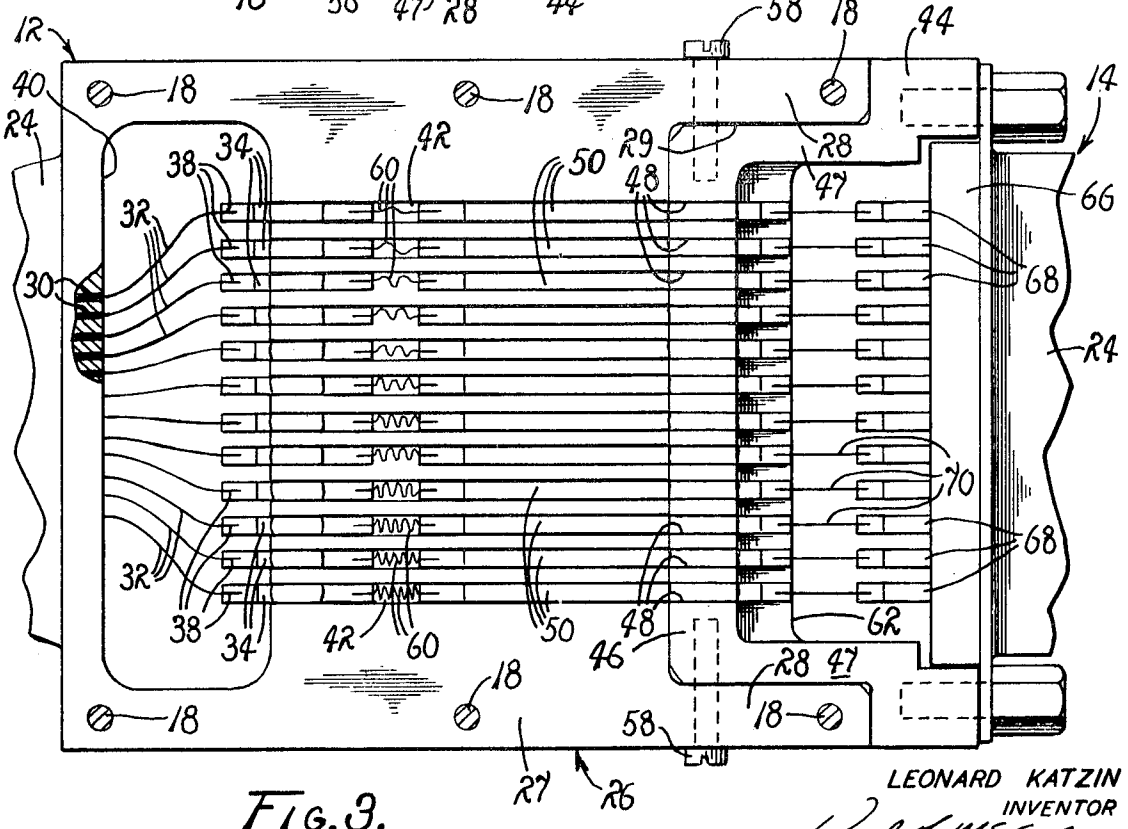



FIG. 3.

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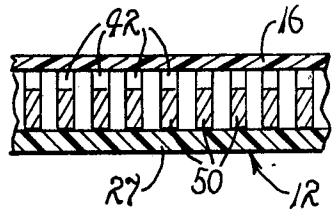



FIG. 4.

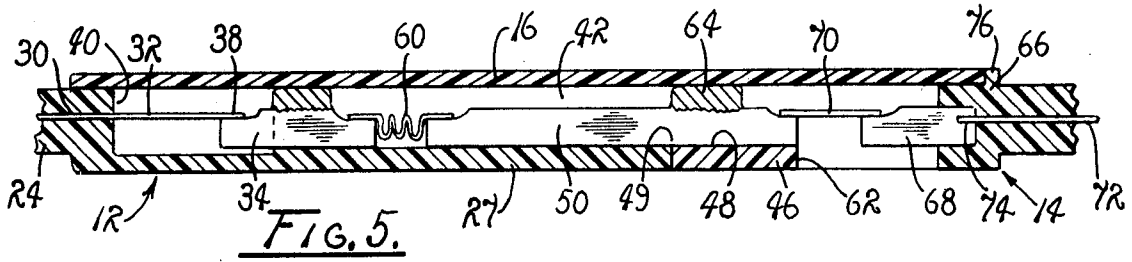



FIG. 5.

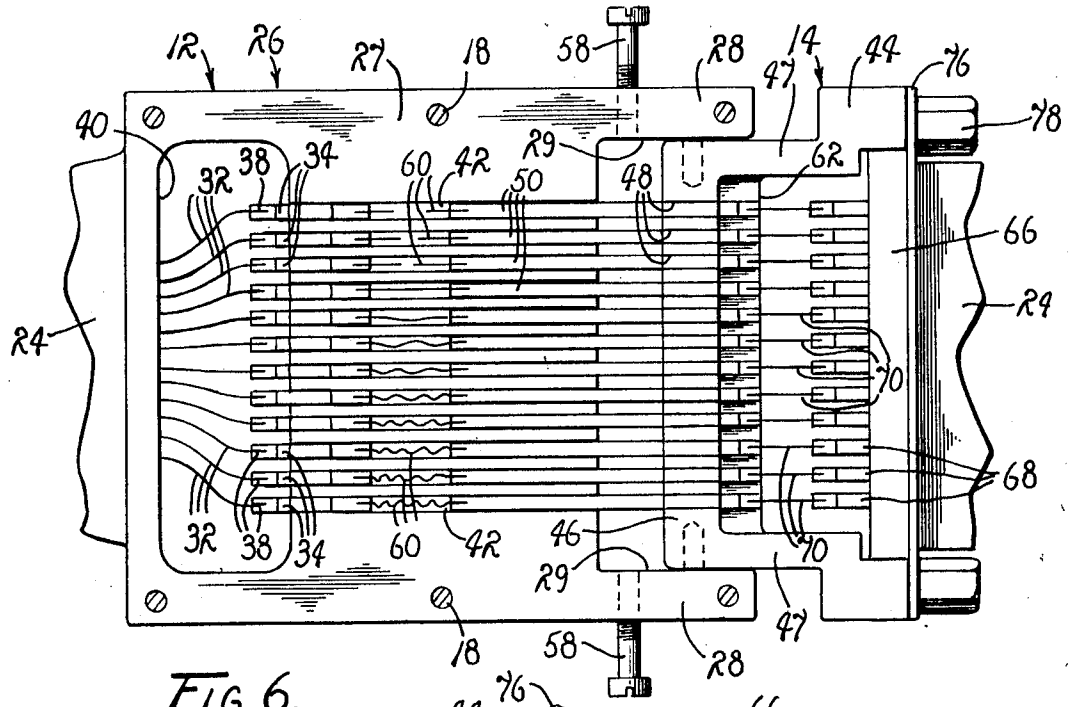



FIG. 6.

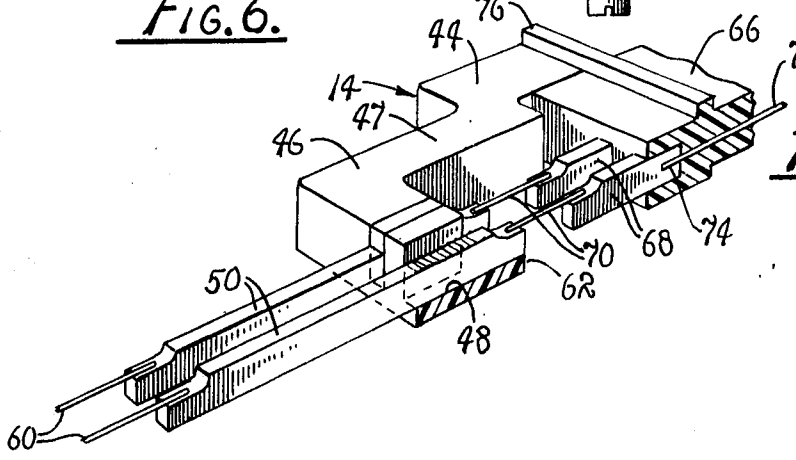



FIG. 7.

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# BREAKAWAY CONNECTOR

## ORIGIN OF INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 435; 42 USC 2457).

## BACKGROUND OF THE INVENTION 1. Field of the Invention

The invention relates to electrical cable connectors and more specifically to a one-shot, breakaway multiwire cable connector particularly suited for use in joining adjacent cable ends of electrical cables of the type often employed as umbilical cables. 2. Description of the Prior Art

Breakaway connectors have long been provided for use with umbilical cables employed in connecting missiles with launch facilities. Such cables, for example, often are utilized in connecting air-launched missiles with a launching craft and in connecting space craft with launch-pad facilities. In practice, such connectors serve temporarily to connect a multiplicity of selected circuits within a missile, or space craft, with selected circuits located within launch facilities in order that the circuits may be energized and/or controlled through externally developed signals while the missile and the launch facilities are in a prelaunch but mated configuration.

Normally, an umbilical cable is formed in two lengths having a pair of adjacent cable ends connected at a breakaway connector which includes a plurality of terminal-connecting leads, interconnecting electrical terminals arranged in opposing units in a manner such that as separation of the units is achieved a simultaneous failure or rupturing of all of the bridging wires occurs. Consequently, the tensile forces normally required in achieving a separation of existing connectors must be sufficient to overcome the total tensile strength of all connectors wires acting in unison.

Because of operational requirements normally imposed on the design of missile launching systems, the umbilical cables currently utilize breakaway connectors custom-fabricated and designed according to specific parameters established for particular environments. Hence, in fabricating the connectors currently employed, extreme caution must be exercised to assure adequate performance of the connector when subject to tensile forces of predetermined magnitudes. Consequently, there currently exists a need for a practical and economic breakaway connector which readily may be employed in various environments while achieving a predictable separation of associated cable ends for umbilical cables and the like.

## OBJECTS AND SUMMARY OF THE INVENTION

It is therefore an object of the instant invention to provide an improved breakaway connector for temporarily joining cable ends of multiwire cables.

It is another object to provide an improved breakaway connector for accommodating a separation of a pair of cable ends in the presence of an applied tensile force of a minimal magnitude.

It is another object to provide a one-shot, breakaway connector for use in coupling the cable ends of multiwire cables for accommodating cable separation as a tensile force sufficient for rupturing a single wire is applied to the connector through the cables.

Another object is to provide an economical and efficient universal cable connector particularly suited for operational use in joining cable ends so as to provide a multiplicity of conductive paths.

Another object is to provide a simplified connector which may be employed for interrupting selected circuits in a given sequence.

These and other objects and advantages are achieved through a simple, economic breakaway connector which includes a mated pair of juxtaposed and separable connector units, each including a plurality of electrical terminals secured to individual leads of an adjacent cable end and interconnected with the terminals of the adjacent unit through a plurality of relatively brittle electrical connector leads of a common diameter but of mutually unique lengths, whereby a one-shot, breakaway separation of the cable ends is achievable through application of a constant forecast a magnitude and duration sufficient sequentially to tension and cause the individual connector leads to fail in a predetermined sequential progression as separation of the connector components is achieved.



## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top plan view of a breakaway connector embodying the principles of the present invention, including a protective cover plate.

FIG. 2 is a top plan view of a portion of the connector of FIG. 1 with a protective cover plate having been removed therefrom, illustrating the relative positions assumed by the terminals of the connector during an assembly thereof.

FIG. 3 is a top plan view of the connector illustrated in FIGS. 1 and 2 on somewhat of an enlarged scale depicting the terminals of the connector when the connector is fully assembled.

FIG. 4 is a fragmentary cross-sectional view taken generally along line 4—4 of FIG. 1.

FIG. 5 is a fragmentary cross-sectional view taken generally along 5—5 of FIG. 1.

FIG. 6 is a top plan view of a connector depicting the relative position of the connector components as connector-separation is achieved.

FIG. 7 is a fragmentary perspective view of selected components of the connector, once connector-separation has been achieved.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning to FIG. 1, a breakaway connector **10**, which embodies the principles of the present invention, is illustrated having a female unit **12** and a male unit **14** disposed in fully mated juxtaposition. as illustrated, a protective cover plate **16** is positioned over the mated male and female units of the connector. Preferably, the plate **16** is secured in place by a plurality of screws **18** and is adapted to be removed from the connector **10** in order that access to the connector components readily may be acquired.

In practice, the male and female units **12** and **14** are employed in coupling adjacent cable ends **20** and **22**, respectively, of multiwire cables in a manner such that a plurality of electrical circuits are established through the connector **10**. As a practical matter, an insulating sheet or protective boot **24** also is protectively positioned over the cable ends in order that the connector **10** is sealed against the elements and is electrically insulated from its operative environment.

The female unit **12** includes an elongated female block **26**, which is fabricated from a suitable nonconductive stock material. The block **26** includes an elongated body **27** terminating in a pair of parallel legs **28** defining therebetween an outwardly directed U-shaped receiver recess **29**, FIG. **6**, which receives therein an adjacent portion of the male unit **14**. Through the end of the block **26** opposite the receiver recess **29**, there is provided a plurality of tubular openings **30** which serve as conduits which receive individual electrical leads or wires **32** of the multiwire cable **20**. The wires **32** are extended and secured to the adjacent ends of rigid conductor bars, which form elongated cable terminals **34** disposed in a parallel relationship. It is to be understood that the individual wires **32** are secured within the tubular openings **30** in any suitable manner, however, it is preferred that the wires be secured therein through the use of a suitable, commercially available epoxy resin applied to the openings after the wires **32** have been received.

The cable terminals 34 also are fabricated from any suitable material such as copper and silver alloys, or the like, and are interconnected with the wires 32 through suitable connectors 38 which, in practice, include spot welds. The terminals 34 are seated in longitudinally extended, parallel slots formed within the female block 26 and are secured therein through any suitable device, including pins, not shown, and/or adhesive materials, such as the aforementioned commercially available epoxy resins, for example.

In order to facilitate a coupling of the wires 32 with the adjacent ends of the terminals 34, an access opening 40 is provided within the body of the female block 26, as best illustrated in FIG. 5, for accommodating access to the adjacent ends of the wires and terminals.

Between the terminals 34 and the opposite end of the female block 26, there are provided a plurality of parallel grooves 42. These grooves are extended coaxially from the terminals 34 and terminate in the transverse surface of the outwardly directed U-shaped receiver 29.

The male unit 14 includes a male block 44 having a stepped terminal portion including a support bracket 46, also of a U-shaped configuration, adapted to be inserted into the U-shaped receiver 29 of the female block 26. The bracket 46, in turn, is provided with an internal recess defined between longitudinally extended parallel legs 47, and a plurality of parallel grooves 48.

The grooves 48 extend from the recess to the grooves 42 in a coaxial relationship therewith. Consequently, when the female block 26 and the male block 44 are brought into a mated relationship, the grooves 42 and 48 establish a plurality of parallel channels 49 extending from the terminals 34 through the support bracket 46 and terminating at the recess formed between the legs 47.

Within each of the channels 49 there is seated an elongated intermediate terminal 50. Each of the terminals 50 is of a bar-shaped configuration and is fabricated from an electrically conductive material similar to material from which the terminals 34 are fabricated. In practice, the terminals 50 slidingly are supported for axial displacement along the surface of the channels 49. Therefore, it is to be understood that the grooves 42 and 48 which form the channel 49 are so surfaced and dimensioned as to accommodate rectilinear reciprocation of the individual terminals 50 with minimal frictional restraint.

In assembling the connector 10, the intermediate terminals 50 initially are seated in a staggered relationship within the coaxially aligned grooves 42 and 48. As best illustrated in FIG. 2, the intermediate terminals 50 are arranged in a uniformly staggered configuration so that the adjacent ends of the cable terminals 34 and the intermediate terminals 50 are separated through uniformly increased distances, whereby the distance between each pair of adjacent ends of the terminals 34 and 50 is unique.

As a practical matter, the terminals 50 are of a common length, therefore, the spacing between the adjacent ends of the terminals 34 and 50 may readily be achieved by employing a stepped spacer block 52 simultaneously applied to he opposite ends of the terminals 50. As shown in FIG. 2, the block 52 includes a plurality of diagonally aligned, transversely stepped surfaces 54, each being adapted to abut an adjacent end of an intermediate terminal 50 in a manner such that the abutted ends of the terminals 50 simultaneously are caused to be positioned in parallel, mutually spaced planes.

Positioning of the block 52 is enhanced by a pair of laterally extended ears 56, which permit the spacer surfaces 54 to be displaced toward the ends of the terminals 50 for axially displacing the intermediate terminals until the ears 56 are caused to engage transverse surfaces 57 formed at the terminal portions of the legs 47 of the support bracket 46. As the spacer block 52 is seated against the surfaces 57, the preferred spacing is established between the adjacent ends of the cable terminals 34 and the intermediate terminals 50.

Where preferred, the female unit 12 and the male unit 14 are retained in a mated relationship through the use of a pair of oppositely directed locking pins 58 extended through the legs 28 of the female block 26 and threadingly received within the external surfaces of the support bracket 46 in a manner such that axial displacement between the bracket 46 and the female block 26 is precluded.

With the intermediate terminals 50 seated in a staggered relationship within the channels 49, the distance between each pair of adjacent ends of the thus paired terminals 34 and 50 is unique. A flexible connector lead 60 of a unique length is extended between the paired ends and is welded or otherwise fixedly secured to the terminals 34 and 50. The connector leads 60 are fabricated from an electrically conductive wire having a suitable modulus of elasticity, such as a selectively heat-treated copper wire. The leads 60 are a common cross-sectional configuration and dimension. Consequently, the individual connector leads 60 are adapted to rupture, or fail, and separate under a common load of a predetermined magnitude.

With the connector leads 60 secured between the adjacent ends of the terminals 34 and 50, the spacer block 52 is removed from the between the legs 47 of the support bracket 46 in order that the distal ends of the intermediate terminals 50 may be forced into a coplanar relationship through an axial displacement of the intermediate terminals 50. This displacement is, in practice, achieved through the use of an alignment block, not shown, which includes a transverse abutment having an unbroken face adapted to engage the ends of the terminals 50, as the block is displaced inwardly toward the recess 47, for axially displacing the terminals 50 along the channels 49 formed by the grooves 42 and 48. As axial displacement of the terminals 50 is achieved, a compressive stress is developed in the flexible connector leads 60 causing the leads to be deformed. Preferably during deformation, the leads 60 are looped or coiled into a selected configuration for thereby enhancing stowage within the female unit 12.

As best illustrated in FIG. 3, the bracket 46 also is provided with a transverse shoulder 62. This shoulder is employed in achieving the selected coplanar relationship for the distal ends of the terminals 50 as the face of the abutment of the alignment block is brought into a contiguous relationship therewith. In any event, it is to be understood that once the flexible leads 60 have been secured between the adjacent ends of the paired terminals 34 and 50, the terminals 50 are axially displaced towards the terminals 34 through a distance sufficient for aligning the ends of the terminals 50 in coplanar relationship with the leads 60 being deformed and stowed between the pairs of adjacent ends of the terminals 34 and 50. Of course, the extent of deformation of the leads 60 is dictated, at least in part, by their lengths.

Once the intermediate terminals 50 have been brought into a selected relationship, as illustrated in FIG. 3, wherein the connector leads 60 are deformed, the intermediate terminals 50 are fixedly secured in place within the grooves 48 of support bracket 46 through the use of mechanical couplings and/or adhesives. As a practical matter, an epoxy of the type employed in securing the terminals 34 in an operative relationship within the female block 26, serves quite satisfactorily for this purpose. It is to be understood that the terminals 50 are fixedly secured within the terminal bracket 46 in a manner such that as relative displacement is imposed on the units 12 and 14, the ends of the intermediate terminals 50 simultaneously are displaced relative to the terminals 34. Therefore, it can be appreciated that as a separating displacement of the terminals 34 and 50 occurs, the connector leads 60 become uncoiled and tensioned with a resulting stress being developed therewithin. It should readily be apparent that the greater stress is developed within the shorter leads 60, as they sequentially are tensioned in response to the displacement of the terminals 34 and 50.

In the event the male block 44, along with its bracket 46, is displaced sufficiently for causing the shortest of the connector leads 60 to rupture or fail, the next shortest of the leads 60 is placed in tension. As tension is applied to the next shortest

lead 60, the stress developed therein is increased sufficiently for causing this lead to separate in a manner similar to that of the preceding lead. Continued displacement of the block 44 ultimately serves to separate all of the connector leads 60. Consequently, separation of the connector 10 can be achieved while employing a force which is substantially constant and of a magnitude sufficient to cause a single one of the connector leads 60 to rupture or fail.

In order to complete a coupling of the adjacent ends of the cables 20 and 22, the male block 44 receives a male connector unit 66, FIG. 3, having a plurality of laterally spaced cable terminals 68 extended in coaxial alignment with the terminals 34 and 50. The adjacent ends of the terminals 50 and 68 are brought into a spaced and paired relationship as the male unit 66 is brought into a fully seated relationship with the male block. To the thus paired adjacent ends of the elongated terminals 50 and 68 there is welded or otherwise fixedly secured a bridging wire 70 while the distal or outermost ends of the terminals 68 are connected with individual wires 72, FIG. 5, of the adjacent cable 22 so that an electrical coupling is established therebetween. Where desired, the wires 72 are fixedly coupled to the terminal 68 by spot welds 74 similar to the welds 38. However, if found convenient, binding posts and the like can be employed in establishing an electrical coupling between the wires 72 nd the terminal 68.

Since the male connector unit 66 is of a commercially available design, a detailed description thereof is omitted in the interest of brevity. However, it is to be understood that the terminals 68 of the male connector unit 66, along with the bridging wires 70, are employed to provide a plurality of electrical leads extending between juxtaposed ends of the individual wires 72 of the cable 22 and the individual intermediate terminals 50 of the connector 10 in order that electrical circuits are established between the wires 72 and the connector leads 60.

In order to avoid applying undesired tension to the bridging wires 70, a retainer plate 76 is provided for mounting the connector 66 on the terminal support bracket 46. The retainer plate 76, as illustrated, is secured to the distal end portions of the legs 47 of the bracket 46 by a plurality of screw-threaded studs 78 extended through the plate and threadably received within the adjacent end surfaces of the legs 47.

Once the connector 10 is assembled, an electrically nonconductive grease or gel, such as, for example, a silicone formulation currently available under the trade name of Dow Corning No. 4, is packed within the voids of the connector 10 for purposes of excluding air and reducing friction as separation of the units 12 and 14 occurs. This formulation or packing, of course, is retained within the connector by the cover plate 16 once the plate is secured in an operative disposition by the screws 18.

While the connector 10 preferably is assembled between juxtaposed ends of the cables 20 and 22, it should be apparent that the connector 10 can be provided with a plurality of bonding posts, not shown, mounted externally of the female block 26 and the male block 44 and electrically interconnected with the terminals 34 and 68 in order that assembly thereof substantially is completed at a remote location so that a coupling of the connector 10 between the cables 20 and 22 is required at the point of use. Additionally, the cables may be fabricated at a location remote from their point of use with the connector 10 being included therebetween.

In any event, once the connector 10 is assembled and connected between the wires 32 and 72 of the cables 20 and 22, respectively, the ends of the multiwire cables are electrically interconnected in order that electrical circuits may be completed therethrough.

## OPERATION

It is believed that in view of the foregoing description, the operation of the device will be readily understood and it will be briefly reviewed at this point. The connector 10 is employed for completing electrical circuits between adjacent end portion of multiwire cables 20 and 22 so that a plurality of electrical circuits are completed therethrough. Locking pins 58 operationally serve to obviate undesired separation of the male and female units 14 and 12, respectively. However, prior to a launch of an associated missile or space craft coupled to its launching facilities through cables 20 and 22, the locking pins 58 are threadingly extracted so that the female unit 12 and the male unit 14 are supported in a mated but readily displaceable relationship.

When separation of the cables 20 and 22 is desired, the female and male units 12 and 14 are separated within the connector 10 by applying tension to the connector 10 in a manner such that the male block 44 is extracted from the receiver recess 29 of the female block 26. This extraction may be achieved manually or, where desired, through an application of forces derived hydraulically or explosively, as dictated by the parameters of its operational environment. As extraction occurs, the intermediate terminals 50 are displaced along the grooves 42 with a resulting tensioning of the individual connector leads 60 being achieved.

As the connector leads 60 are tensioned, tensile stress is developed therewithin, with the shorter leads initially being subjected to the greater stress. As the tension is increased, through an additional displacement of the male unit 14, relative to the female unit 12, the shortest of the leads 60 is caused to rupture or part, whereupon the next shortest lead 60 is subjected to stress of a magnitude which builds to a magnitude sufficient to effect its rupture or failure. Since each of the individual connector leads 60 is of a unique length, when compared to the remaining leads of the connector 10, the leads 60 sequentially and individually are sufficiently tensioned for effecting a progressive and sequential rupture thereof. Consequently, continued displacement of the male block 44, of the male unit 14, relative to the female block 26, of the female unit 12, serves to progressively and sequentially separate all of the connector leads 60.

Obviously, during unit separation only a single connector lead 60 is significantly stressed at any given instant. Therefore, the force required in effecting separation of the connector 10 is a constantly applied force having a magnitude sufficient for rupturing a single one of the connector leads 60. As indicated in FIG. 7, once the male block 44 completely is extracted from the female block 26, the intermediate terminals 50, along with the associated ends of the ruptured connector leads 60, are withdrawn and disassociated from the female block 26 so that total separation is achieved and circuit disruption is achieved.

In the event it is desired to employ the connector 10 in an environment wherein the applied force is of a varying magnitude, the lengths and diameters of the individual connector leads 60 may be varied accordingly so that desired failure of the individual leads is achieved in accordance with the specific load requirements of the environment. Furthermore, if desired, the leads 60 of the connector 10 are suited for use as a timing mechanism whereby selected circuits are interrupted in predetermined timing sequence for achieving a timed sequential operation of selected missile and craft components.

In view of the foregoing, it should be readily apparent that the connector which embodies the principles of the present invention is a simplified connector having particular utility in interconnecting umbilical cords extended between missiles, or space craft, and the associated launching facilities in an environment wherein separation of the cables is to be achieved with a force of a minimal magnitude being applied thereto.

Although the invention has been herein shown and described in what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of the invention, which is not to be limited to the illustrative details disclosed.

What is claimed is:

1. A breakaway multicircuit connector comprising:

A. a pair of separable members having corresponding circuit segments which it is desired electrically to intercon-

nect and to disconnect when said members are moved relatively from each other; and

B. conductors individually interconnecting the corresponding circuit segments, said conductors being severable when subjected to tension and of graduated length whereby they are severed as the members are moved apart.

2. A connector for a multiwire cable comprising:

A. a first connector unit including therein a first plurality of laterally aligned terminals;

B. a second connector unit seated in coaxial juxtaposition with said first connector unit including therein a second plurality of laterally aligned terminals arranged in a coaxially spaced relationship with said first terminals;

C. support means supporting said units for mutual displacement whereby connector-separating displacement may be imparted to said units; and

D. circuit means including a plurality of flexible connector leads of mutually unique lengths interconnecting the terminals of the first plurality of terminals with the terminals of said second plurality of terminals in a paired relationship, whereby as displacement of the first units is effected tensioning of the flexible connectors is achieved in a sequence dictated by the lengths of the flexible connectors.

3. The connector of claim 2 wherein each terminal of the first plurality of terminals comprises a rigid connector bar having one end thereof fixedly secured to he first connector unit and the distal portion thereof extended toward the second connector unit, and each terminal of the second plurality of terminals comprises a rigid connector bar having one end thereof rigidly coupled with he second connector unit and the distal portion thereof extended toward the first plurality of terminals.

4. The connector of claim 3 wherein the distal ends of the first plurality of terminals are disposed in a first transverse plane, and the distal ends of the second plurality of terminals are disposed in a second transverse plane paralleling said first transverse plane.

5. The connector of claim 4 wherein the support means includes means defining a plurality of parallel slots adapted to receive and slidingly support the terminals of said second plurality of terminals as the second connector unit is displaced relative to the first connector unit.

6. The connector of claim 5 wherein said circuit means further includes a plurality of connector bars seated in said slots and connected at the opposite ends thereof with said plurality of flexible connectors and said second plurality of terminals.

7. The connector of claim 6 further including first coupling means electrically coupling said first plurality of terminals with a first plurality of electrical leads, and a second coupling means electrically coupling the second plurality of terminals with a second plurality of electrical leads.

8. A breakaway connector for a multiwire electrical cable comprising:

A. a female connector unit;

B. a male connector unit displaceably disposed in juxtaposition with said female unit;

C. coupling means adapted to releasably support the units in a mated relationship;

D. a plurality of female terminals fixedly mounted within said female unit;

E. a plurality of male terminals fixedly mounted within said male unit adapted to be displaced from said female terminal as the male connector unit is displaced from juxtaposition with said female unit;

F. a plurality of elongated connector terminals coupled with the male terminals and slidingly supported within said female unit adapted to be displaced relative to the female terminals as said male unit is displaced; and

G. a plurality of flexible connector leads, each of a unique length, interconnecting said female and male terminals and having a predetermined resiliency adapted to separate under predetermined stress, whereby as the male element is displaced from juxtaposition with the female element, each of the connector leads is stressed independently of the other connector leads, whereby said connector leads may be sequentially stressed beyond their elastic limits for sequentially separating the plurality of leads.

9. The connector of claim 8 further comprising coupling means coupling adjacent ends of electrical cables with the male and female connector units.

10. A connector for a pair of multiwire cables comprising:

A. a first connector unit and a second connector unit seated in juxtaposition with said first connector unit and supported to be displaced from juxtaposition for mutually separating said units;

B. first coupling means mounted in said first connector unit including a first plurality of terminals fixedly secured to said first connector unit and electrically connected with individual wires of a first multiwire cable;

C. second coupling means mounted in said second connector unit including a second plurality of terminals fixedly secured to said second connector unit and electrically connected with individual wires of a second multiwire cable; and

D. third coupling means comprising,

1. a plurality of bar-shaped terminals electrically connected with said second plurality of terminals, fixedly secured to said second connector unit, and supported for axial displacement relative to said first connector unit, and

2. means for establishing a plurality of sequentially interruptable electrical circuits between said first plurality of terminals and said second plurality of terminals including a plurality of uninterrupted connector leads extending between and connecting the plurality of bar-shaped terminals with the first plurality of terminals.