The disclosure generally relates to shielded electrical cables (100) that form a shielded electrical ribbon cable. In particular, at least six individual conductor sets (110A-110F) of insulated conductors (112, 113) are shielded by shielding films (130, 140) that include cover portions (150) and pinched portions (155) separating the cover portions (150), over a cable width (W) of at least 1.6 cm to form a shielded electrical ribbon cable.
WIDE MULTI-CHANNEL RIBBON CABLE

Technical Field

The present disclosure relates generally to electrical cables.

Background

Electrical cables for transmission of electrical signals are well known. One common type of electrical cable is a coaxial cable. Coaxial cables generally include an electrically conductive wire surrounded by an insulator. The wire and insulator are surrounded by a shield, and the wire, insulator, and shield are surrounded by a jacket. Another common type of electrical cable is a shielded electrical cable comprising one or more insulated signal conductors surrounded by a shielding layer formed, for example, by a metal foil. To facilitate electrical connection of the shielding layer, a further un-insulated conductor is sometimes provided between the shielding layer and the insulation of the signal conductor or conductors. Both these common types of electrical cable normally require the use of specifically designed connectors for termination and are often not suitable for the use of mass-termination techniques, i.e., the simultaneous connection of a plurality of conductors to individual contact elements, such as, e.g., electrical contacts of an electrical connector or contact elements on a printed circuit board.

Summary

The disclosure generally relates to shielded electrical cables that form a shielded electrical ribbon cable. In particular, at least six individual conductor sets of insulated conductors are shielded by shielding films that include cover portions and pinched portions separating the cover portions, over a cable width of at least 1.6 cm to form a shielded electrical ribbon cable. In one aspect, the present disclosure provides a shielded electrical cable that includes at least six conductor sets extending along a length of the cable and being spaced apart from each other along a width of the cable, each conductor set including two or more insulated conductors; the first and second end conductors are separated by a width distance of at least 1.6 cm. The shielded electrical cable further includes first and second shielding films disposed on opposite first and second sides of the cable, the first and second shielding films including cover portions and pinched portions arranged such that, in transverse cross section, the cover portions of the first and second shielding films in combination substantially surround each conductor set, and the pinched portions of the first and second shielding films in combination form pinched portions of the cable on each side of each conductor set. The shielded electrical cable still further includes an adhesive layer bonding the first shielding film to the second shielding film in the pinched portions of the cable. A maximum separation between the cover portions of the first and second shielding films is D; a first
minimum separation between the pinched portions of the first and second shielding films is \( dl \); and \( dl/D \) is less than 0.25. A second minimum separation between the cover portions of the first and second shielding films in regions within the conductor sets and between neighboring insulated conductors is \( d_2 \); \( d_2/D \) is greater than 0.33; and an impedance of each conductor set over a length of at least 1 meter, is within 10% of an average impedance of the conductor set over the same length.

The above summary is not intended to describe each disclosed embodiment or every implementation of the present disclosure. The figures and the detailed description below more particularly exemplify illustrative embodiments.

**Brief Description of the Drawings**

Throughout the specification reference is made to the appended drawings, where like reference numerals designate like elements, and wherein:

- FIG. 1 shows a schematic cross-sectional view of a shielded electrical cable;
- FIGS. 2A-2F show schematic cross-sectional views of exemplary shielded electrical cables;
- FIG. 3A shows a schematic cross-sectional view of a shielded electrical cable;
- FIG. 3B shows an overhead schematic view of the shielded electrical cable of FIG. 3A; and
- FIG. 4 shows a plot of the impedance data from the shielded electrical cable of FIGS. 3A-3B.

The figures are not necessarily to scale. Like numbers used in the figures refer to like components. However, it will be understood that the use of a number to refer to a component in a given figure is not intended to limit the component in another figure labeled with the same number.

**Detailed Description**

Many high speed electronic connection schemes require more than one parallel transmission channel; e.g., coax or twinax pairs of transmission channels. Some emerging schemes may use at least eight parallel differential channels or more. One such scheme for uniform pinched ribbon cable constructions include the twinax cables described, for example, in U.S. Patent Application Serial No. 61/378877 entitled CONNECTOR ARRANGEMENTS FOR ELECTRICAL CABLES (Attorney Docket No. 66887US002), filed on August 31, 2010.

As the number and speed of interconnected devices increases, electrical cables that carry signals between such devices need to be smaller and capable of carrying higher speed signals without unacceptable interference or crosstalk. Shielding is used in some electrical cables to reduce interactions between signals carried by neighboring conductors. Many of the cables described herein have a generally flat configuration, and include conductor sets that extend along a length of the cable, as well as electrical shielding films disposed on opposite sides of the cable. Pinched portions of the shielding films between adjacent conductor sets help to electrically isolate the conductor sets from each other. Many of the cables
also include drain wires that electrically connect to the shields, and extend along the length of the cable. The cable configurations can help to simplify connections to the conductor sets and drain wires, reduce the size of the cable connection sites, and/or provide opportunities for mass termination of the cable.

In some approaches, a semi-rigid cable can be formed using a thicker metal or metallic material as the shielding film. For example, aluminum or other metal may be used in this approach without a polymer backing film. The aluminum (or other material) is passed through shaping dies to create corrugations in the aluminum which form cover portions and pinched portions. The insulated conductors are placed in the corrugations that form the cover portions. If drain wires are used, smaller corrugations may be formed for the drain wires. The insulated conductors and, optionally, drain wires, are sandwiched in between opposite layers of corrugated aluminum. The aluminum layers may be bonded together with adhesive or welded, for example. Connection between the upper and lower corrugated aluminum shielding films could be through the un-insulated drain wires.

In exemplary embodiments, the cover regions of the shielded electrical cable include concentric regions and transition regions positioned on one or both sides of a given conductor set. Portions of a given shielding film in the concentric regions are referred to as concentric portions of the shielding film and portions of the shielding film in the transition regions are referred to as transition portions of the shielding film. The transition regions can be configured to provide high manufacturability and strain and stress relief of the shielded electrical cable. Maintaining the transition regions at a substantially constant configuration (including aspects such as, e.g., size, shape, content, and radius of curvature) along the length of the shielded electrical cable may help the shielded electrical cable to have substantially uniform electrical properties, such as, e.g., high frequency isolation, impedance, skew, insertion loss, reflection, mode conversion, eye opening, and jitter.

Additionally, in certain embodiments, such as, e.g., embodiments wherein the conductor set includes two insulated conductors that extend along a length of the cable that are arranged generally in a single and effectively as a twinaxial cable that can be connected in a differential pair circuit arrangement, maintaining the transition portion at a substantially constant configuration along the length of the shielded electrical cable can beneficially provide substantially the same electromagnetic field deviation from an ideal concentric case for both conductors in the conductor set. Thus, careful control of the configuration of this transition portion along the length of the shielded electrical cable can contribute to the advantageous electrical performance and characteristics of the cable.

The widest cable created using previous pinched ribbon cable constructions (defined by the distance between the outer edge of the two outer channels) was on the order of 15 mm, and contained eight or fewer channels (eight only for 32 AWG wire). The need for larger wire gauges and/or larger connector pitches along with the larger number of channels has made it difficult to fit all channels for a connector or a cable in less than a 15 mm width. Two or more cables in a side-by-side placement is a
possible solution, but has drawbacks including the need to manage multiple cables, and the reduced density due to the presence of at least two extra cable edges. Further, there is increased manufacturing cost for multiple ribbons due to increased materials, increased waste, and possibly a more narrow process width. A single wide cable solution is superior to multiple discrete channels or multiple ribbon cable.

A wide, multi-channel ribbon cable for high speed data transfer requires each channel to have well-controlled geometry, which results in a well-controlled impedance. A pinched shield construction that uses at least one continuous shielding film on one side of the cable forms the channel by shaping the films on at least one side of each channel. Any dimensional changes or imbalances may produce imbalances in capacitance and inductance along the length of the parallel portion. This in turn may cause impedance differences along the length of the pinched region and impedance imbalances between adjacent conductor sets. At least for these reasons, control of the spacing between the shielding films may be desired. In some cases, the pinched portions of the shielding films in the pinched regions of the cable on both sides of a conductor set are spaced apart within about 0.05 mm of each other. With a wide cable and with many channels, it can become increasingly difficult to achieve the necessary uniform precision across the cable width. One measure of consistency within the wide cable is a comparison between the high speed electrical properties of each channel relative to the others.

In some cases, the impedance of one channel relative to the others (if meant to be the same impedance) and also the impedance consistency of a channel along the cable length can be an important parameter. For high speed interconnections, the level of this impedance control should be within 10% from channel to channel (if the channels are meant to be the same impedance) and within 10% over a reasonable distance of each channel (1 meter for example). If the channels are not meant to be the same impedance (for example 100 ohms vs 85 ohms nominal impedance) then another measure is for each channel to be within 10% or 5% of a nominal value, or its mean value over a given length. Any impedance changes along the length of a transmission line may cause power to be reflected back to the source instead of being transmitted to the target. Ideally, the transmission line will have no impedance variation along its length, but, depending on the intended application, variations up to 5-10% of a target impedance value, such as, e.g., 50 Ohms, over a given length, such as, e.g., 1 meter, may be acceptable.

The conductor sets and shielding film may be cooperatively configured in an impedance controlling relationship. In one aspect, this means that the partial coverage of the conductor sets by the shielding film is accomplished with a desired consistency in geometry along the length of the shielded electrical cable such as to provide an acceptable impedance variation as suitable for the intended application. In one embodiment, this impedance variation is less than 5 Ohms and preferably less than 3 Ohms along a representative cable length, such as, e.g., 1 m. In another aspect, if the insulated conductors are arranged effectively in a twinaxial and/or differential pair cable arrangement, this means that the partial coverage of the conductor sets by the shielding film is accomplished with a desired consistency in
geometry between the insulated conductors of a pair such as to provide an acceptable impedance variation as suitable for the intended application. In some cases, the impedance variation is less than 2 Ohms and preferably less than 0.5 Ohms along a representative cable length, such as, e.g., 1 m.

Near-end crosstalk and/or far-end crosstalk can be important measures of signal integrity or shielding in any electrical cable, including the disclosed cables and cable assemblies. Grouping signal lines (e.g. twinax pairs or other conductor sets) closer together in a cable and in a termination area tends to increase undesirable crosstalk, but the cable designs and termination designs disclosed herein can be used to counteract this tendency. The subject of crosstalk in the cable and crosstalk within the connector can be addressed separately, but several of these methods for crosstalk reduction can be used together for enhanced crosstalk reduction. To increase high frequency shielding and reduce crosstalk in the disclosed cables, it is desirable to form as complete a shield surrounding the conductor sets (e.g. twinax pairs) as possible using the two shielding films on opposite sides of the cable. It is thus desirable to form the shielding films such that their cover portions, in combination, substantially surround any given conductor set, e.g., at least 75%, or at least 80, 85, or 90%, of the perimeter of the conductor set. It is also often desirable to minimize (including eliminate) any gaps between the shielding films in the pinched zones of the cable, and/or to use a low impedance or direct electrical contact between the two shielding films such as by direct contact or touching, or electrical contact through one or more drain wires, or using a conductive adhesive between the shielding films. If separate "transmit" and "receive" twinax pairs or conductors are defined or specified for a given cable or system, high frequency shielding may also be enhanced in the cable and/or at the termination component by grouping all such "transmit" conductors physically next to each another, and grouping all such "receive" conductors next to each other but segregated from the transmit pairs, to the extent possible, in the same ribbon cable. The transmit group of conductors may also be separated from the receive group of conductors by one or more drain wires or other isolation structures as described elsewhere herein. In some cases, two separate ribbon cables, one for transmit conductors and one for receive conductors, may be used, but the two (or more) cables are preferably arranged in a side-by-side configuration rather than stacked, so that advantages of a single flexible plane of ribbon cable can be maintained.

FIG. 1 shows a schematic cross-sectional view of a shielded electrical cable 100 according to one aspect of the disclosure. Details concerning the construction of such shielded ribbon cables can be found, for example, in U.S. Patent Application Serial No. 61/378877 entitled CONNECTOR ARRANGEMENTS FOR ELECTRICAL CABLES (Attorney Docket No. 66887US002), filed on August 31, 2010. Shielded electrical cable 100 includes six conductor sets 110a - 110f, optional sideband conductors 110g, optional first and second ground/drain conductors 120a, 120b, a first shielding film 130, and a second shielding film 140 disposed on opposite sides of the shielded electrical cable 100. It is to be understood that shielded electrical cable 100 can include more than six conductor sets if desired, and also

-5-
can include any number of optional sideband conductors, and any number of optional ground/drain conductors. The placement of each of the conductor sets, sideband conductors and ground/drain conductors is also not restricted; however, in some cases it may be desirable to provide as much symmetry to the cable as possible in order to minimize cross-talk between electrical signals.

Each of the six conductor sets 110a-110f, the optional sideband conductors 110g, and optional first and second ground/drain conductors 120a, 120b, are substantially surrounded by a cover portion 150 that is formed by the combination of the first and the second shielding films 130, 140. Each of the cover portions 150 are bounded on each side by a pinched portion 155 that is formed by pinching the first and second shielding films 130, 140, together. An adhesive layer 116 bonds the first shielding film 130 to the second shielding film 140 in the pinched portions 155 of the shielded electrical cable 100. In some cases, the adhesive layer 116 can also extend to within the cover portions 150 that surround each of the six conductor sets 110a-110f, the optional set of sideband conductors 110g, and optional first and second ground/drain conductors 120a.

In one particular embodiment, each of the six conductor sets 110a-110f include two insulated conductors comprising a first conductor 112 surrounded by a first insulator 113, and a second conductor 114 surrounded by a second insulator 115. In some cases, each of the six conductor sets 110a-110f can include either more or fewer than two insulated conductors; however, two insulated conductors can be preferred. In some cases, one or more of the six conductor sets 110a-110f can also include one or more ground/drain conductors (not shown) within the cover portions 150, as described elsewhere.

The shielded electrical cable 100 can have a width "W" measured from the outside edge of the end conductors (e.g., the first conductor set 110a and the sixth conductor set 110f) greater than about 1.6 cm, as shown in FIG. 1. In some cases, the width "W" can be greater than about 2 cm, or even greater than about 3 cm. The first shielding film 130 and the second shielding film 140 in the cover portions 150 can include a maximum separation "D", and the first shielding film 130 and second shielding film 140 in the pinched portions 155 can include a minimum separation "dl". "D" and "dl" are related such that the ratio "dl/D" is less than about 0.25, or less than about 0.20, or less than about 0.15, or even less than about 0.10.

The packing density of conductor pairs in the shielded electrical cable can be related to the a minimum separation "d2" between the cover portions of the first and second shielding films in regions within the conductor sets 110a-110f and between neighboring insulated conductors, where "d2" and "D" are related such that the ratio "d2/D" is greater than about 0.33, or greater than about 0.40, or greater than about 0.45, or even greater than about 0.50.

Electrical characteristics of a cable determine the cable's suitability for high speed signal transmission. Electrical characteristics of a cable include characteristic impedance, insertion loss, crosstalk, skew, eye opening, and jitter, among other characteristics. The electrical characteristics can
depend on the physical geometry of the cable, as previously discussed, and can also depend on the material properties of the cable components. Thus it generally desirable to maintain substantially uniform physical geometry and/or material properties along the cable length. For example, the characteristic impedance of an electrical cable depends on the physical geometry and material properties of the cable. If a cable is physically and materially uniform along its length, then the characteristic impedance of the cable will also be uniform. However, non-uniformities in the geometry and/or material properties of the cable can cause mismatches in the impedance at the points of non-uniformity.

In some cases, the physical geometry and material properties of the described shielded electrical cable 100 may be controlled to produce minimal variations in the characteristic impedance over each conductor set 110a-110f of the shielded electrical cable 100, when measured over a cable length of at least one meter. In some cases, minimal variations in the characteristic impedance over each conductor set 110a-110f of the shielded electrical cable 100, can be when measured over a cable length of at least two meters. The minimal variation in the characteristic impedance of each conductor set 110a-110f can be within 10%, or within 8%, or within 5%, or even within 1% of an average impedance of the conductor set 110a-110f over the same length.

FIGS. 2A-2F show schematic cross-sectional views of exemplary shielded electrical cables, according to one aspect of the disclosure. All of the elements "D", "d1", "d2", "W", and 112-155, as described in FIG. 1 apply equally to FIGS. 2A-2F as apparent to one of skill in the art; however, for brevity the descriptions are not duplicated.

In FIG. 2A, shielded electrical cable 200 includes a first through eighth conductor sets 200a-200g that are distributed along a width "W" greater than about 1.6 cm. A first and second ground/drain wire 220a, 220b are disposed at either end of the cable.

In FIG. 2B, shielded electrical cable 201 includes a first through sixth conductor sets 201a-201f that are distributed along a width "W" greater than about 1.6 cm. An additional seventh and eighth conductor set 201g, 201h extend the width of the cable beyond 1.6 cm, and a first and second ground/drain wire 221a, 221b are disposed at either end of the cable.

In FIG. 2C, shielded electrical cable 202 includes a first through sixth conductor sets 202a-202f that are distributed along a width "W" greater than about 1.6 cm. A first and second ground/drain wire 222a, 222b are disposed at either end of the cable.

In FIG. 2D, shielded electrical cable 203 includes a first through sixth conductor sets 203a-203f and a group of four sidebands 203g, which are distributed along a width "W" greater than about 1.6 cm. A first and second ground/drain wire 223a, 223b are disposed at either end of the cable.

In FIG. 2E, shielded electrical cable 204 includes a first through sixth conductor sets 204a-204f and a wide minimum separation "d2E" between the third and fourth conductor sets 204c, 204d, all
distributed along a width "W" greater than about 1.6 cm. A first and second ground/drain wire 224a, 224b are disposed at either end of the cable.

In FIG. 2F, shielded electrical cable 205 includes a first through sixth conductor sets 205a-205f that are distributed along a width "W" greater than about 1.6 cm. In shielded electrical cable 205, at least one of the shielding films (e.g., second shielding film40) as shown in FIG. 1) remains flat as described, for example, in U.S. Patent Application Serial No. 61/378877 entitled CONNECTOR ARRANGEMENTS FOR ELECTRICAL CABLES (Attorney Docket No. 66887US002), filed on August 31, 2010.

Examples

An example of a shielded electrical cable 300 is shown in FIG. 3A, which shows a schematic cross-sectional view of the cable. The shielded electrical cable 300 had an aluminum foil first shielding film 330 and an aluminum foil second shielding film 340 on either side of the cable, bonded together with adhesive layer 316. The cable was prepared according to the procedure described in U.S. Patent Application Serial No. 61/378877 entitled CONNECTOR ARRANGEMENTS FOR ELECTRICAL CABLES (Attorney Docket No. 66887US002), filed on August 31, 2010. The aluminum foil was 0.072 mm thick, and the adhesive layer comprised a polyolefin based adhesive that was 0.0254 mm thick and enclosed nine conductor sets 310a-310i of paired conductors. The nine conductor sets 310a-310i were disposed in a width "W" of 2.44 cm. Each of the paired conductors included two 30 AWG silver plated copper wires insulated with polyolefin having an outer diameter of 0.79 mm. The shielded electrical cable 300 also included a group of five sidebands 310j (each sideband was 30 AWG tin plated copper wires insulated with polyolefin having an outer diameter of 0.79 mm) in the center, as well as 4 uninsulated 30 AWG tin plated copper drain wires within the construction as shown.

FIG. 3B shows an overhead schematic view of the shielded electrical cable 300. The electrical characteristics of the cable (e.g., impedance) was measured using a time domain reflectometer (TDR, Model CSA8000 available from Tektronix Inc, Beaverton, OR) at a rise time of 35 ps, for different lengths of the cable as shown in FIG. 3B. A first impedance measurement "1T" was recorded for each of the conductor sets 310a-310i at the length "L"=2 meters between first end 301 and cable end 310. A section "12"=0.2 meters was removed, and a second impedance measurement "12" was recorded for each of the conductor sets 310a-310i for the remaining length "L" - "11" = 1.8 meters. The process was repeated by subsequently removing four more 0.2 meter sections and measuring the impedance at each of the remaining lengths. FIG. 4 shows a plot of the impedance data from the shielded electrical cable of FIGS. 3A-3B, ranging from one meter to two meters, in 0.2 meter intervals.

Following are a list of embodiments of the present disclosure.
Item 1 is a shielded electrical cable, comprising: at least six conductor sets extending along a length of the cable and being spaced apart from each other along a width of the cable, each conductor set including two or more insulated conductors; first and second end conductors separated by a width distance of at least 1.6 cm; first and second shielding films disposed on opposite first and second sides of the cable, the first and second shielding films including cover portions and pinched portions arranged such that, in transverse cross section, the cover portions of the first and second shielding films in combination substantially surround each conductor set, and the pinched portions of the first and second shielding films in combination form pinched portions of the cable on each side of each conductor set; and an adhesive layer bonding the first shielding film to the second shielding film in the pinched portions of the cable; wherein: a maximum separation between the cover portions of the first and second shielding films is D; a first minimum separation between the pinched portions of the first and second shielding films is dl; dl/D is less than 0.25; a second minimum separation between the cover portions of the first and second shielding films in regions within the conductor sets and between neighboring insulated conductors is d2; d2/D is greater than 0.33; and an impedance of each conductor set over a length of at least 1 meter, is within 10% of an average impedance of the conductor set over the same length.

Item 2 is the shielded electrical cable of item 1, wherein the width distance is at least 2 cm.

Item 3 is the shielded electrical cable of item 1 or item 2, wherein the width distance is at least 3 cm.

Item 4 is the shielded electrical cable of item 1 to item 3, wherein dl/D is less than 0.20.

Item 5 is the shielded electrical cable of item 1 to item 4, wherein dl/D is less than 0.15.

Item 6 is the shielded electrical cable of item 1 to item 5, wherein dl/D is less than 0.10.

Item 7 is the shielded electrical cable of item 1 to item 6, wherein d2/D is greater than 0.40.

Item 8 is the shielded electrical cable of item 1 to item 7, wherein d2/D is greater than 0.45.

Item 9 is the shielded electrical cable of item 1 to item 8, wherein d2/D is greater than 0.50.

Item 10 is the shielded electrical cable of item 1 to item 9, wherein the impedance of each conductor set over the length of at least 1 meter, is within 8% of the average impedance of the conductor set over the same length.

Item 11 is the shielded electrical cable of item 1 to item 10, wherein the impedance of each conductor set over the length of at least 1 meter, is within 5% of the average impedance of the conductor set over the same length.

Item 12 is the shielded electrical cable of item 1 to item 11, wherein the impedance of each conductor set over the length of at least 1 meter, is within 1% of the average impedance of the conductor set over the same length.
Item 13 is the shielded electrical cable of item 1 to item 12, wherein the impedance of each conductor set over the length of at least 2 meters, is within 10% of the average impedance of the conductor set over the same length.

Item 14 is the shielded electrical cable of item 1 to item 13, wherein the impedance of each conductor set over the length of at least 2 meters, is within 8% of the average impedance of the conductor set over the same length.

Item 15 is the shielded electrical cable of item 1 to item 14, wherein the impedance of each conductor set over the length of at least 2 meters, is within 5% of the average impedance of the conductor set over the same length.

Item 16 is the shielded electrical cable of item 1 to item 15, wherein the impedance of each conductor set over the length of at least 2 meters, is within 1% of the average impedance of the conductor set over the same length.

Unless otherwise indicated, all numbers expressing feature sizes, amounts, and physical properties used in the specification and claims are to be understood as being modified by the term "about". Accordingly, unless indicated to the contrary, the numerical parameters set forth in the foregoing specification and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by those skilled in the art utilizing the teachings disclosed herein.

All references and publications cited herein are expressly incorporated herein by reference in their entirety into this disclosure, except to the extent they may directly contradict this disclosure. Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations can be substituted for the specific embodiments shown and described without departing from the scope of the present disclosure. This application is intended to cover any adaptations or variations of the specific embodiments discussed herein. Therefore, it is intended that this disclosure be limited only by the claims and the equivalents thereof.
What is claimed is:

1. A shielded electrical cable, comprising:
   at least six conductor sets extending along a length of the cable and being spaced apart from each other along a width of the cable, each conductor set including two or more insulated conductors;
   first and second end conductors separated by a width distance of at least 1.6 cm;
   first and second shielding films disposed on opposite first and second sides of the cable, the first and second shielding films including cover portions and pinched portions arranged such that, in transverse cross section, the cover portions of the first and second shielding films in combination substantially surround each conductor set, and the pinched portions of the first and second shielding films in combination form pinched portions of the cable on each side of each conductor set; and
   an adhesive layer bonding the first shielding film to the second shielding film in the pinched portions of the cable;

wherein:
   a maximum separation between the cover portions of the first and second shielding films is D;
   a first minimum separation between the pinched portions of the first and second shielding films is dl;
   dl/D is less than 0.25;
   a second minimum separation between the cover portions of the first and second shielding films in regions within the conductor sets and between neighboring insulated conductors is d2;
   d2/D is greater than 0.33; and
   an impedance of each conductor set over a length of at least 1 meter, is within 10% of an average impedance of the conductor set over the same length.

2. The shielded electrical cable of claim 1, wherein the width distance is at least 2 cm.

3. The shielded electrical cable of claim 1, wherein the width distance is at least 3 cm.

4. The shielded electrical cable of claim 1, wherein the impedance of each conductor set over the length of at least 1 meter, is within 5% of the average impedance of the conductor set over the same length.
5. The shielded electrical cable of claim 1, wherein the impedance of each conductor set over the length of at least 0.5 meter, is within 10% of the average impedance of the conductor set over the same length.

6. The shielded electrical cable of claim 1, wherein the impedance of each conductor set over the length of at least 0.5 meter, is within 1% of the average impedance of the conductor set over the same length.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01B11/20
ADD. H01B7/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>WO 2010/148157 AI (3M INNOVATIVE PROPERTIES CO [US]; GUDEL DOUGLAS B [US])</td>
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<td>23 December 2010 (2010-12-23) page 2, line 5 - line 10; figure 1</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:
  “A” document defining the general state of the art which is not considered to be of particular relevance
  “E” earlier application or patent but published on or after the international filing date
  “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  “O” document referring to an oral disclosure, use, exhibition or other means
  “P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search 22 February 2013
Date of mailing of the international search report 04/03/2013

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Tel. (+31-31) 340-2040, Fax: (+31-31) 340-3016

Hi I lmayr, Heinrich
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<td>US 4 155 613 A (BRANDEAU EDWARD P [US]) 22 May 1979 (1979-05-22) figure 3</td>
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