NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO ATTN OF: GP

(NASA-Case-GSC-11215-1) PROCESS FOR MAKING RF SHIELDED CABLE CONNECTOR ASSEMBLIES AND THE PRODUCTS FORMED THEREBY Patent (NASA) 7 p CSCL 09A

N73-28083

Unclas
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TO: KSI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,744,128

Government or Corporate Employee : U.S. Government

Supplementary Corporate Source (if applicable) : ____

NASA Patent Case No. : GSC-11,215-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

Yes [ ] No [X]

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter

Elizabeth A. Carter
Enclosure
Copy of Patent cited above

PATENTED JUL 10 1973 3,744,128

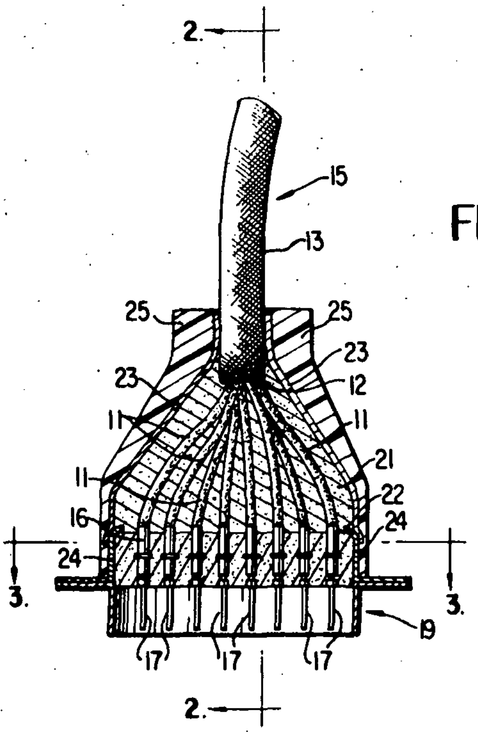


FIG. 1

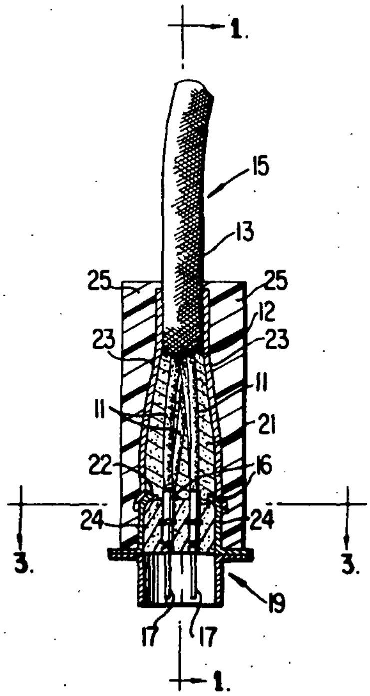
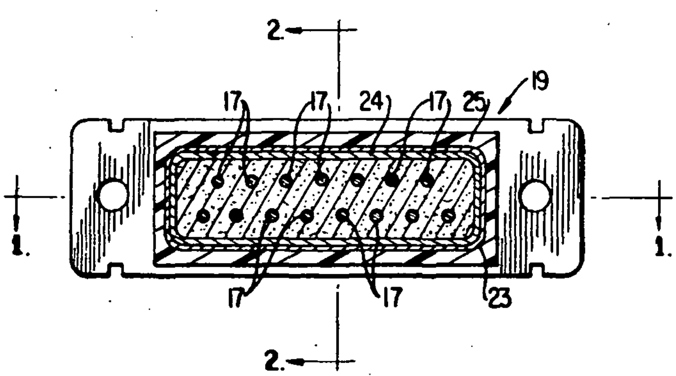


FIG. 2

FIG. 3



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United States Patent [19]

Fishar et al.

[11] **3,744,128**

[45] **July 10, 1973**

[54] **PROCESS FOR MAKING R. F. SHIELDED CABLE CONNECTOR ASSEMBLIES AND THE PRODUCTS FORMED THEREBY**

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[73] Assignee: **The United States of America as represented by the Adminstrator of the National Aeronautics and Space Administration,** Washington, D.C.

[22] Filed: **Feb. 12, 1971**

[21] Appl. No.: **114,873**

[52] **U.S. Cl.** .... **29/629,** 29/628, 29/630, 29/630 A

[51] **Int. Cl.** **H02g 15/00**

[58] **Field of Search** .... 339/63, 64, 143 ; 29/600, 601, 629; 317/101 A

[56] **References Cited**

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Primary Examiner—Charles W. Lanham
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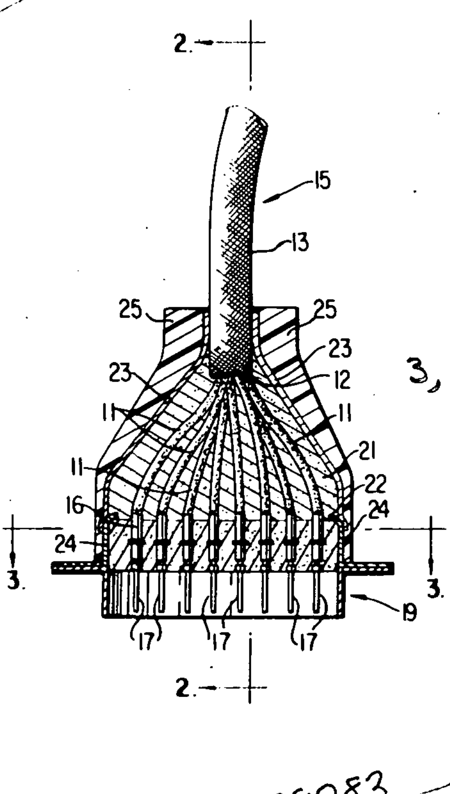
Attorney—R. F. Kempf, E. Levy and John R. Manning

[57] **ABSTRACT**

A process for making R. F. shielded cable connector assemblies and the products formed thereby is described. The process basically comprises the steps of: potting wires of a shielded cable between the cable shield and a connector housing to fill in, support, rigidize and insulate the individual wires contained in the cable; coating the thusly formed potting with an electrically conductive material so as to form an entirely encompassing adhering conductive path between the cable shield and the metallic connector housing; and, forming a protective jacket over the conductive coating between the cable shield and the connector housing.

7 Claims, 3 Drawing Figures



3,744,128

reduce to 80%

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PROCESS FOR MAKING R. F. SHIELDED CABLE CONNECTOR ASSEMBLIES AND THE PRODUCTS FORMED THEREBY

ORIGIN OF THE INVENTION

The invention described herein was made by employees of the U.S. Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates to connectors and, more particularly, to a process for making radio frequency (R. F.) shielded connectors and the products formed thereby.

One of the major problems with electronic systems that operate in R. F. environments occurs at the cable connectors, and more particularly at the junction between R. F. shielded cables and the connector terminals of the cable connectors. Electronic systems that operate in an R. F. environment usually include interconnectors of shielded cables wherein a plurality of signal carrying internal wires are electrically shielded by a braided conductive member. The wires in the shielded cables interconnect with the terminals of the cable connectors; and the shields of the cables are connected in various manners to grounded metallic connector housings of the cable connector. Contact between cable connectors and terminal blocks achieves electrical ground. By the configuration just described, the internal electronic signal carrying wires are, for the most part, protected from extraneous electromagnetic and radio frequency signals. With this arrangement, however, there is a problem of providing total R. F. shielding in the area where the braided shield joins with the connector housing. It is in this region that the signal carrying internal wires have limited R. F. protection. This region can be more particularly defined as the gap formed essentially between the end of the cable shield and the metallic housing of the cable connector. That is, because this gap is only partially shielded, extraneous electromagnetic and radio frequency signals are often picked up by the internal wires, resulting in deteriorated signals.

Various attempts have been made to solve the foregoing problem by providing a supplemental shield between the cable connector and the end of the cable shield. However, these attempts have not been entirely satisfactory. Very often, the solution has been to extend the metallic casing of the cable connector toward the shield of the cable. Normally, a two-piece structure is thusly created. The major difficulty with this solution is that a bulky generally non-flexible cable connector is created. Moreover, the resultant cable connector is expensive to produce because it is larger and more complicated. In addition, often a gap still exists between the cable shield and the aperture in the cable connector through which the shielded internal wires pass. This gap must be filled with solder or some other suitable electrical connecting material in order to provide an entirely enclosing yet non-flexible shield.

Another, somewhat similar attempt to solve the foregoing problem is illustrated in U.S. Pat. NO. 3,322,855, issued to May et al. for Electrical Connection. That patent discloses potting individually shielded wires with a rigid conductive potting material inside of a container or boot that forms a part of a cable connector assembly. One of the major problems with this solution is that the internal wires of male and female connectors become rigidly fixed, resulting in a rigid non-accommodating male pin, female socket interfacing. The problem with a rigid pin structure is that male cable connector pins and female terminal block sockets, designed to mate easily therewith, may not do so when the pins of the male connectors or female sockets cannot "float" to allow mutual adjustment for positive electrical contact. In addition, an expensive and bulky connector structure is formed. Further, the cables are required to approach the cable connector from one specific direction, regardless of the constraints placed on the system because of the environment of use. That is, in some environments it may be desirable for the cable or cables to approach the cable connector from other than the usual approach paths. However, this desire cannot be fulfilled by assemblies of the type disclosed in the foregoing patent.

As will be appreciated by those skilled in the art, when connectors or other electronic systems are potted, it is desirable to provide a potting compound that cures pin hole free, particularly, when the resultant structure is to be used in a vacuum environment, such as the vacuum environment of space. Hence, an additional disadvantage of "gap" shields that include metallic containers and potting compounds is the difficulty in determining whether the potting compounds are entirely free of pin holes or bubbles.

Various other attempts have been made to solve the shielding problem occurring at the gap between a shielded cable and a cable connector; however, they have also been unsatisfactory either for the reasons set forth above or for other reasons. One of the major difficulties with most prior art connector structures is the formation of a rigid connection at the point where the shielded cable connects to the structure that shields the "gap." Because the termination is rigid, cable stressing tends to concentrate at this region, increasing the possibility of cable shield breakage at the stressed area thereby resulting in the potential loss of R. F. protection.

Therefore, it is an object of this invention to provide a new and improved process for making R. F. shielded cable connector assemblies.

It is a further object of this invention to provide a new and improved process for making shielded cable connector assemblies in which the cable and connector structures are held together in a semi-rigid manner, which allows some flexing.

It is a still further object of this invention to provide a new and improved process for providing potted R. F. shielded connector cable assemblies that allow the initial potting to be examined to determine if it is pin hole free and has no accidently coated connector insertion pins.

It is still another object of this invention to provide an improved R. F. cable connector assembly which is launch vibration proof, thermal cycle resistant and has very low outgassing qualities in vacuum at 125° C.

It is a still further object of this invention to provide new and improved connector structures formed in accordance with the processes of the invention.

SUMMARY OF THE INVENTION

In accordance with principles of this invention, a process for making radio frequency (R. F.) shielded connector cable assemblies and the products formed thereby is provided. The basic process comprises the steps of: potting the signal carrying wires contained in a shielded electronic cable at the gap formed between the end of the cable shield and the metallic connector housing to fill in, support, rigidize, and insulate the individual wires; coating the thusly potted wires with an electrically conductive, somewhat flexible material so as to form an adhering conductive path between the cable shield and the connector housing; and, applying a substantially flexible, tough protective jacket material over the conductive coating that overlaps and supports both the cable and the connector housing.

In accordance with further principles of this invention, preferably, the potting step utilizes materials which, while being generally rigid, are also somewhat flexible when cured. In addition, preferably, the potting material includes a fluorescent dye which allows that material to be examined under ultraviolet light after the potting step is completed to determine whether or not pin holes, bubbles and uncoated areas are present in the potting material. Further, preferably, the cured conductive coating utilizes the least amount of a conductive material, such as silver, that will allow the coating to exhibit a low resistance (e.g., 0.1 ohm or lower) between the shield and the connector housing.

In accordance with still further principles of this invention, the supporting protective jacket is applied by casting within a mold surrounding the area to be protected. A wax block is shaped to the contours desired. A suitable resin is cast about the wax block, leaving the base exposed for subsequent removal of the wax pattern. After room temperature curing of the mold the wax block is removed. The internal surface of the cavity is next coated with a thin acrylic resin barrier that is allowed to dry, the barrier is used to prevent contamination of the resin to be cast within the mold. Thereafter, the coated, potted region of the cable-connector combination is surrounded by the mold and the protective jacket material is injected into the mold cavity and allowed to cure to the required contour. Finally, the mold is removed.

It will be appreciated from the foregoing summary of the invention that a new and improved process for making R. F. shielded connector cable assemblies and the products formed thereby is provided by the invention. The process overcomes the prior art requirement of a rigid and bulky case to shield the gap between the shield of the cable and the connector housing. In addition, the process overcomes the formation of a highly stressed, rigid connection joint at the point where the coated shielding structure meets the cable which heretofore has resulted in cable shield breakage. Further, the invention can be utilized to provide a "shield in place" whereby the direction that the cable approaches the connector becomes of little importance. Moreover, the invention is suitable for use with a wide variety of connectors and is not limited to use with a particular connector design structure as are many prior art devices for shielding the gap between the connector cable and the connector housing. Furthermore, because the invention, in its preferred form, utilizes materials which achieve a pinhole free, low outgassing assembly, the process is suitable for use with connectors that are to be used in remote environments, such as the vacuum of space, with minimal condensing effects on critical experiments such as radiometers and/or optics.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing objects and many of the attendant advantages of the invention will become more readily appreciated as the same becomes better understood from the following detailed description when taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a cross-sectional view along line **1—1** of FIGS. **2** and **3** and illustrates a preferred embodiment of the invention;

FIG. **2** is a cross-sectional diagram along lines **2—2** of FIGS. **1** and **3**; and,

FIG. **3** is a cross-sectional view along lines **3—3** of FIGS. **1** and **2**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As will be better understood from the following description, the drawings illustrate a structure or product formed in accordance with the process of the invention and are to be taken as illustrative and not limiting. The drawings will be referred to during the discussion of the various process steps so that the various substructures formed during the process can be more easily understood.

In general, the process of the invention comprises the steps of: potting the signal carrying wires between termination of the cable shield and the connector housing; coating totally the thusly formed potting with a semi-flexible, conductive material which adheres to and electrically connects the cable shield and metallic connector housing; and, forming a protective supportive jacket around the coated conductive material, connector housing and cable, the latter two being located adjacent to the coated conductive material. This process, employing compatible resin materials in the potting, conductive coating, and protective jacket, results in the formation of a composite R. F. shielding metal filled, conducting polymer, and supportive protective structure of which the conductive coating thereof joins two R. F. shield metals (braided cable shield and connector housing) in a manner that protects the previously R. F. exposed signal carrying wires located between the two metals.

The initial or first step of the overall process consists essentially of filling, supporting, rigidizing and insulating, by a potting material **21**, the individual signal carrying wires **11** as they emerge from end **12** of metallic shield **13** formed around the outside of the cable **15** and fan out to connect to the individual terminals **16** formed integral with the pins **17** of the connector structure **19**. Preferably, potting material **21** is a fumed silica (e.g., Cabosil MS–5), thixotropic prepolymer system. It is grease-like in consistency and highly viscous when prepared. More specifically, preferably, the potting material **21** used contains the following ingredients in the indicated amounts by weight:

Solithane C-113	30.0 gms
Solithane C-113-300	21.9 gms
Cabosil MS-5	3.4 gms
Dubutyl tin dilaurate	0.05 gms
Vyac Luminescer 174	0.05 gms

Such a potting material was used in one actual process carried out in accordance with the teachings of the invention and performed highly successfully.

Solithane C-113 is a polyester diisocyanate prepolymer and Solithane C-113-300 is a polyol curing agent, both being obtainable from the Thiokol Chemical Company, Trenton, N.J. These two ingredients cure to a polyurethane resin. Cabosil MS-5, a thixotropic agent for increasing resin viscosity, is formed of finely subdivided fumed silica having a minimum purity of 99.8 percent and a particle size of 0.012 microns. It and other suitable types are obtainable from the Cabot Corporation, Boston, Mass. Dibutyl tin dilaurate is a cure accelerator for the prepolymer system and is obtainable from the General Electric Company, Waterford, New York. Vyac Luminescer 174, a fluorescent dye, is an aromatic heterocyclic that requires an exitation source of around 3,650° A. for optimized fluorescence in the blue-green visible range. It is obtainable from American Cyanamid Corporation, Boundbrook, N.J.

When the foregoing ingredients are formulated and cured they become a tough, flexible, solid polyurethane material capable of fluorescing. This material has very low outgassing properties in a vacuum environment at 125° C., hence, it is suitable for use in the vacuum of space, particularily when used near critical optical experiments

Turning now to the application of the potting material just described, the precured thixotropic material is first outgassed in a vacuum of approximately 10^{-2} torr or lower. Thereafter, the material is inserted into a pressure gun cartridge (20 cc capacity) and dispensed through a pressure gun having an orifice nozzle size of about 1.65 millimeters in diameter, 50.8 mm long. These dimensions are preferable but not limiting. The pressure gun, normally activated by about 4.9 kgms/cm² nitrogen pressure, is utilized to apply or inject potting material **21** between and about the signal carrying wires **11** and in the gap existing between end **12** of cable **15** and the posterior end **22** of connector structure **19**. Because of the non-sagging nature of the potting material **21**, it remains and cures in the region where it is applied with very little subsequent flow regardless of the angle of its application.

It will be appreciated from the foregoing description of the first step of the process that a polymeric potted structure (wires **11** embedded in cured potting material **21**) is subsequently achieved. The potting is not hard and brittle as in many prior art connectors, rather it is tough and flexible. Further, the pins (mating elements) **17** of the connector structure **19** retained their "floating" feature to provide ease of connection with respect to the female "floating" sockets of a mating terminal connector.

It will also be appreciated that the use of a fluorescent ingredient allows the potting to be checked to determined whether or not pin holes developed when determine potting step was performed. More specifically, the fluorescent ingredient is of a nature that easily dissolves in and disperses throughout the potting resin mix. Preferably, the fluorescent material is uniformly dispersed in the uncured potting material with a blender. The resultant blended potting material is then vacuum degassed prior to pressure gun application. After the potting material has been applied, it is inspected for pin holes, air bubbles and uncoated areas. This is done by using a UV (ultraviolet) lamp, such as a USVL-25 lamp which is obtainable from Ultraviolet Products Inc., San Gabriel, Calif. This UV lamp is rich in 3,650° A. wavelength energy and causes the potting resin to fluoresce so that the foregoing defects are easily observed. Should any voids or air bubbles be noted, they are filled in before the potting material is cured to its final state.

The second step in the process comprises applying a conductive coating **23** over the cured, solid potting material **21** and areas of the shield and connector housing adjacent to the potting material. The conductive coating **23** must adhere to the shield **13** on the cable and to the metallic housing **24** of the connector structure **19** and must entirely encompass or enclose the potting materials around the R. F. exposed wires. If desired, the metallic connector housing **24** may be sanded and cleaned prior to the application of the conductive coating **23** for improved adherence thereto. Preferably, the conductive coating **24** is a silver filled flexible polyurethane resin material that exhibits a low resistance between the cable shield and the metallic connector housing **24** when cured, e.g., 0.1 ohm or lower. Preferably, the conductive coating **23** is applied when the potting material **21** is still slightly tacky in order to provide good adherence thereto.

Preferably, the resin of the conductive coating contains the following ingredients in the indicated amounts by weight:

Solithane C-113	30.0gms.
Solithane C-113-300	21.9gms
Dibutyl tin dilaurate	0.05gms

These materials are the same as and obtainable from the sources set forth above.

Also, preferably, the final conductive coating contains the following ingredients in the indicated amounts by weight:

Resin of conductive coating (Formulation immediately preceding)	3.0gms
Hexane (C.P. ACS)	1.5gms
Silver flakes (Silflake 135)	14.0gms

Such a conductive coating was used in the process and performed highly successfully.

Silflake 135 is a silver flake type particle material having a minimum purity of 98 percent. This material is obtainable from the Handy Harman, Co., New York, N.Y. and is sized such that 90 percent of it will pass through a 325 mesh screen with 10 percent being retained on the screen. Hexane is a hydrocarbon solvent and is obtainable from Fisher Scientific Co., Pittsburg, Pa.

When the conductive coating is almost completely cured, the last step of the process is performed. It comprises the formation of a protective jacket **25** that encompasses part of the connector housing **24**, the newly applied and substantially cured conductive R. F. shield **23** and part of the metallic shield **13** of the cable **15**. The preferred method of forming the protective jacket is as follows: a wax block, with a generally rectangular base, is formed to have the external contours, volume and size of the protective jacket. A silicone room temperature curing elastomer is cast about the wax block, leaving the generally rectangular base of the wax block exposed. A cavity is formed therein when the wax block (pattern) is removed from the cured silicone elastomer. Thereafter, the cavity surface is coated by spraying thereon a thin solution of acrylic polymer barrier material which is allowed to dry. The acrylic polymer barrier while not essential where curing is accomplished at room temperature, must be used where curing is done at elevated temperatures. In the latter case, the barrier material prevents urethane resin poisoning which normally inhibits adequate cure.

Thereafter, the thusly formed mold, after being sliced longitudinally on one of its sides, is mounted about the metallic connector housing **24**, conductive coating **23**, and part of the cable **15**. The elastomeric mold is tightly fitted at its base to the connector housing; the slice is then made leak proof with Teflon tape; and the cable end of the mold is adjusted to be substantially uniformly spaced around the cable **15**. A liquid resin, to be formed into the protective jacket material **25**, is next injected into the mold cavity and allowed to cure. After the liquid resin has cured to form the supportive, protective jacket material, the mold is removed. The result is a tough, encapsulated, permanent R. F. shielded structure which can be handled, flexed, and withstand vibration without fear of R. F. protection loss.

Preferably, the liquid resin forming the protective jacket material contains the following ingredients in the indicated amounts by weight:

Solithane C-113	30.0gms.
Solithane C-113-300	21.9gms.
Rutile R-960	0.25gms.
Dibutyl tin dilaurate	0.025gms.

All of the materials except Rutile R–960 have been described above and a source indicated therefor. Rutile R–960 is basically titanium dioxide (TiO_2) of at least 89 percent purity. In addition, aluminum oxide (Al_2O_3) to a maximum of 3 percent and, silicon oxide (SiO_2) to a maximum amount of 8 percent are contained therein. Rutile R–960, obtainable from the E. I. Dupont Company, Wilmington, Del., is used in this system as a white coloring agent.

The foregoing material cures, tack free, to an opaque, flexible, whitish polyurethane polymer. Tack-free cure takes about 48 hours at room temperature, with complete cure being accomplished in seven days; however, this can be modified by the inclusion of additional cure accelerator, dibutyl tin dilaurate, (about twice that for room temperature cure) so that curing time will occur within 24 hours at elevated temperatures.

While the protective jacket has been described as being molded within a cavity about the areas to be covered, it should be understood that it can be applied directly without the use of the mold cavity. However, if the process be performed in this manner, there would be less likelihood of obtaining a uniform symmetrical shape having a smooth surface. Where this would be tolerable, the use of the molding technique would not be a requirement. Instead, the precured urethane material formulation for the protective jacket can be thickened with about 3.4 grams of Cabosil MS–5 so that it can be smeared over the desired region and cured.

It will be appreciated that the process of the invention is rather uncomplicated. However, it overcomes the prior art problems set forth above. More specifically, the invention provides a supportive yet somewhat flexible connector structure. That is, a stiff connection between the metallic shield and the connector housing is avoided yet a complete shield is provided to ground absorbed R. F. signals. Further, the approach path of the cable with regard to the connector housing is not limited to a few degrees as are many prior art structures. Moreover, the invention provides a means for analyzing the potted portion of the structure to determine whether or not air bubbles or other defects are formed therein. It will be appreciated that such defects could create problems if the connector is to be used in an extreme environment, such as the vacuum of space.

In general, the resultant product of the invention includes a thin conductive coating R. F. shield that can flex if necessary and which has low ohmic resistance. Furthermore, the potting is insured to be pin hole free. Moreover, there is positive interlocking and adhesion to the metallic cable shield and to the connector assembly by the potting material conductive coating, and supportive, protective jacket. In addition, the invention can be practiced in situ on a spacecraft or on a production line with a wide variety of connector housings. Because the initial uncured material of the potting material is grease-like in consistency or thixotropic in nature, it cannot run into the connector and thereby reduce previously designed tolerances or insulate conductive connector pins. Further, it has low outgassing properties; hence, it is useful in a vacuum environment. In addition, all process stages are compatible since the same resin forms the base of all layers. In other words, there is nothing to inhibit adhesive because all of the materials are locked together by a homogenous resin. Finally, the resin allows the pins of the connector structure to be free floating whereby mating is not inhibited, as occurs with many prior art structures wherein the potting is completely rigid.

It will be appreciated from the foregoing description that a preferred embodiment of the process of the invention and the product formed thereby has been described. However, it will also be appreciated that various changes can be made in the process and the resultant product without departing from the spirit and scope of the invention. Hence, the invention can be practiced otherwise than as specifically described herein.

What is claimed is:

1. A process for making R. F. shielded cable connector assemblies comprising the steps of:

potting the R. F. exposed region of unsupported individual wires, contained in a R. F. shielded cable at the gap formed between the R. F. shielded cable and a connector structure to which the wires are connected, by applying a flexible potting material thereto to fill in, support, partially rigidize and insulate the individual wires;

coating the entire exterior surface of the potting and portions of the adjacent connector housing and R. F. shielding member of the cable with an electrically conductive material to form a totally enveloping adhering electrically conductive path between the R. F. shielding member of the cable and the connector housing; and,

forming a supportive, protective jacket over the conductive coating from and including a portion of the cable to and including a portion of the connector housing.

2. A process for making R. F. shielded cable connector assemblies as claimed in claim **1** wherein the potting material, the electrically conductive material and the protective jacket all include a similar resin base.

3. A process for making R. F. shielded cable connector assemblies as claimed in claim **2** wherein said electrically conductive material includes particles of silver.

4. A process for making R. F. shielded cable connector assemblies as claimed in claim **3** wherein said potting material includes a fluorescent dye.

5. A process for making R. F. shielded cable connector assemblies as claimed in claim **4** wherein said potting material is a thixotropic urethane resin system.

6. A process for making R. F. shielded cable connector assemblies as claimed in claim **5** wherein the formation of said protective jacket comprises the substeps of:

forming a pattern by shaping a wax block to a predetermined contour;

casting a resin mold about said wax block;

removing said wax block after said resin mold cures;

mounting the thusly formed resin mold about the electrical conductive material, the connector housing and the part of the shield of the R. F. shielded cable adjacent to the electrically conductive material; and,

injecting a protective jacket material into the mold cavity.

7. A process for making R. F. shielded cable connector assemblies as claimed in claim **6** comprising the further substeps of:

coating the interior surface of the mold cavity with a thin coating of acrylic resin after removing said wax block.

* * * * *