

April 4, 1967

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3,312,929

SEALING OF CRIMPED ELECTRICAL CONNECTORS

Filed Aug. 24, 1964

3 Sheets-Sheet 1

FIG. 1

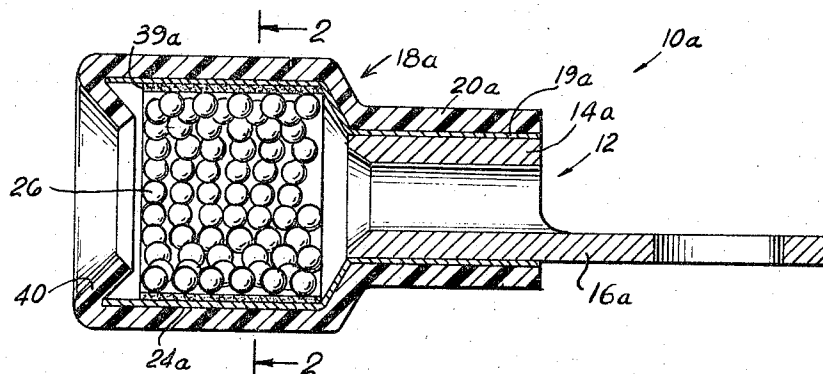


FIG. 2

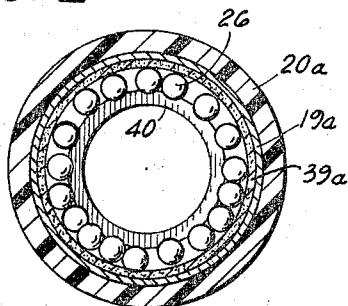
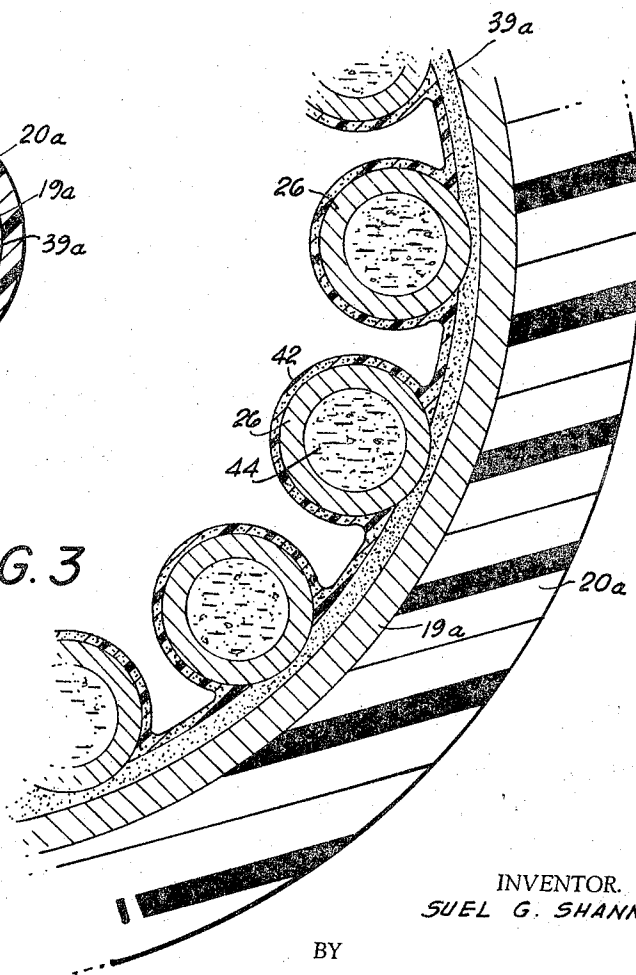


FIG. 3



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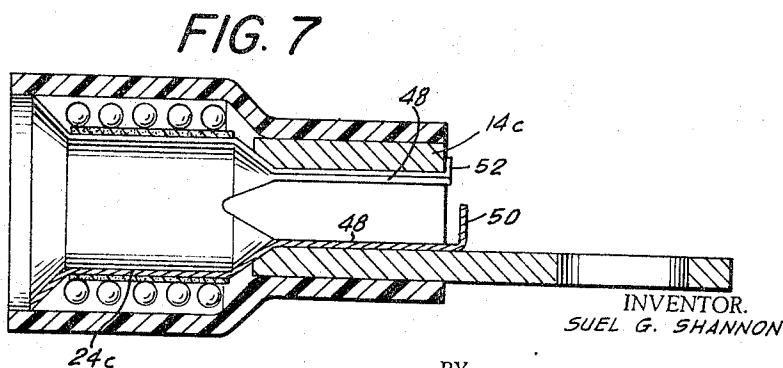
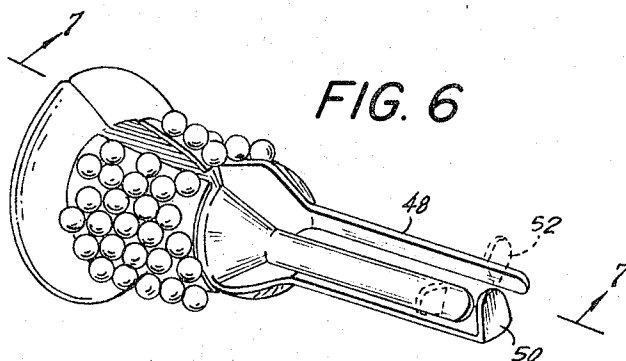
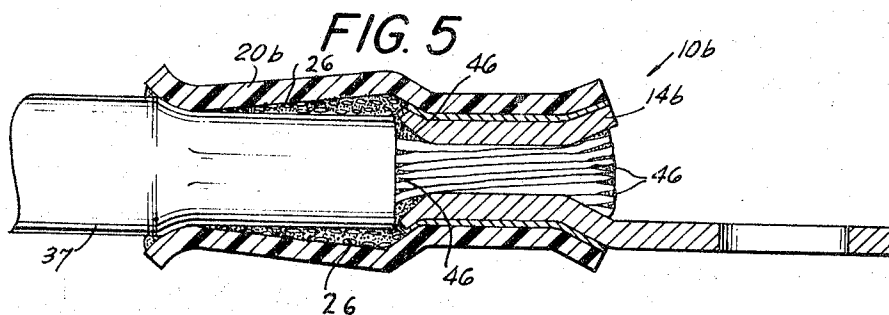
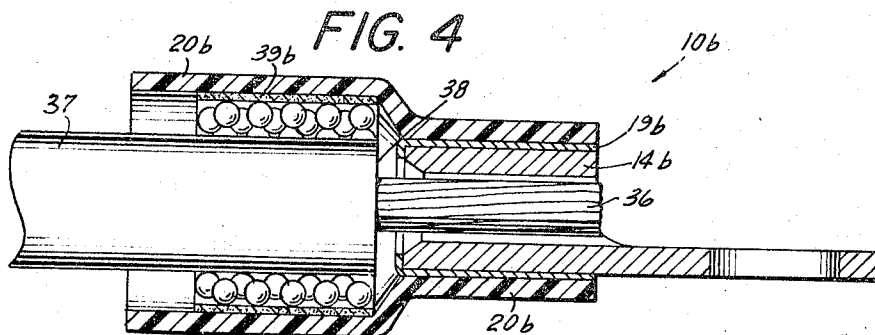
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3 Sheets-Sheet 2



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# SEALING OF CRIMPED ELECTRICAL CONNECTORS

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3 Sheets-Sheet 3

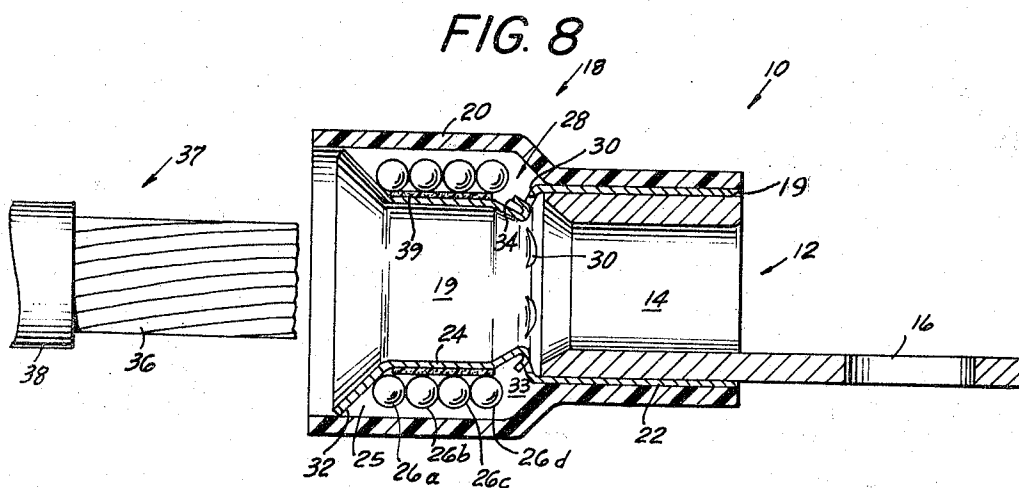


**FIG. 9**

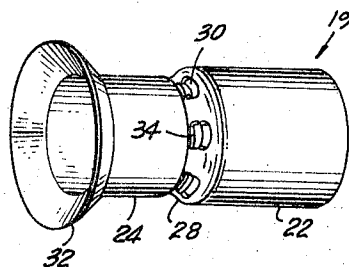
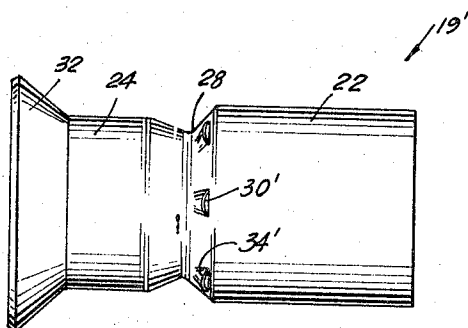


FIG. 10



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## SEALING OF CRIMPED ELECTRICAL CONNECTORS

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19 Claims. (Cl. 339—115)

This invention relates to electrical connectors for conductors, and more particularly to improved solderless crimp-type connectors.

Literally billions of pre-insulated crimped electrical connections have been made over the last two decades and given years of reliable use under all kinds of exacting conditions such as on airplanes and space rockets. In spite of this impressive performance record, it has been found that with advancing technology there is a continual demand for ever increasing quality for every individual electrical connection both in initial and continued service performance. Not only must the connections be superior mechanically and electrically but they should also be statistically reliable. This demand for quality has been greatly aided by the sealed crimped connections disclosed by M. S. Frant and myself in our prior application, Ser. No. 178,835, filed Mar. 12, 1962, issued Mar. 29, 1966, as Patent No. 3,243,758, of which this application is an improvement. In the preferred embodiment therein taught an epoxy system stored in the connector is activated by crimping, which releases and mixes the liquid components, and results in a connection which mechanically has superior pull-out, temperature cycling, and vibration break-down resistance and electrically maintains superior conductivity due to its ability to avoid deterioration from corrosive environments.

Having once recognized the advantages to be gained by applying an epoxy, or similar multi-component electrical contact-treating systems, to a freshly crimped connector; or the even more surprising advantages gained by applying such systems, especially a dielectric like epoxy (while curing), to the incipient connection just prior to or early in the crimping cycle, the problem then became how effectively to store the epoxy resin component and its hardener component separately and yet have it readily available in measured amounts for simplified mixing and application at the time the connector is crimped to a wire. Our patent, mentioned above, discloses some novel connectors for integrally accomplishing these aims by storing the components separately on the connector itself and activating the mixture and application thereof merely by crimping. The present invention is directed to significant improvements in such connectors for accomplishing the foregoing objects, all in a connector which is acceptable to a potential customer, e.g. because it looks essentially like previous connectors which are known and trusted and because it is possible to be applied with little or no retooling, and yet it gives superior results at commercially competitive prices.

It is an object of the present invention to produce solderless connectors having storage capsules for liquids which exclude capsule shell material from the electrical contact areas in the crimped connector. It is a further object to produce such solderless connectors which employ standard crimping techniques and tools and require little or no modification thereof.

Still another object is to protect said capsules from accidental breakage, dust, and other similar damage before crimping.

Another object is to provide a means to ensure that the crimp breaks open the stored capsules, preferably early in the crimp cycle, expresses therefrom substantially all of the liquid components stored within the cap-

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sules, and effectively mixes these components thereby activating the liquid system. An additional object is to urge these mixed components toward the electrical contact areas while restricting their escape from the connector.

It is also an object to provide such connectors which are easily manufactured and assembled to enable these connectors with capsules to be competitively priced with prior-art solderless connectors.

It is still further an object to prevent the crimping tools from becoming excessively contaminated with the liquids; and preferably not at all contaminated.

In this specification the accompanying drawings we have shown and described preferred embodiments of our invention and have suggested various alternatives and modifications thereof; but it is to be understood that these are not intended to be exhaustive and that many other changes and modifications can be made within the scope of the invention. These suggestions herein are selected and included for purposes of illustration in order that others skilled in the art will more fully understand the invention and the principles thereof and will thus be enabled to modify it and embody it in a variety of forms, each as may be best suited to the conditions of a particular use.

In the accompanying drawings:

FIG. 1 is a side view, in vertical section, of a connector according to the present invention;

FIG. 2 is an end view, in vertical section, taken along lines 2—2 of FIG. 1;

FIG. 3 shows a portion of the structure of FIG. 2 on an enlarged scale for purposes of clarity to show greater detail;

FIG. 4 is a side view, in vertical section, showing another embodiment of a connector according to the present invention in position on a properly stripped insulated wire prior to crimping;

FIG. 5 shows the connector of FIG. 4 after it has been affixed to a wire end by crimping;

FIG. 6 is a perspective view of a capsule carrier for use in another connector embodying the present invention;

FIG. 7 is a side view, in vertical section of a connector showing the capsule carrier of FIG. 6 positioned therein;

FIG. 8 is a side view, in vertical section, of still another preferred embodiment of a connector according to the present invention;

FIG. 9 is a perspective view of a capsule carrier for the connector illustrated in FIG. 8; and

FIG. 10 is an elevational view of a capsule carrier similar to that of FIG. 9, but with a modification in the shape of the access holes.

FIGURES 1 to 3 show a simplified version of the present invention. The connector 10a includes a standard crimp terminal 12 having a ferrule 14a and a tongue 16a. The sleeve 19a of terminal 12 is closely fitted, or even bonded, to the outer insulation tube 20a. The joined sleeve 19a and tube 20a, forming the capsule carrier means 18a, are advantageously clinched into position on said ferrule 14a. The sleeve 19a carries the capsules 26 on the interior of its carrier portion 24a. The capsules 26 are fixed to the carrier by adhesive 39a (similarly see 39 and 39b in FIGURES 8 and 4, respectively). To protect the capsules from injury without, especially during wire insertion, the tube 20a extends beyond sleeve 19a and folds back within the end of sleeve 19a to form a protective lead-in funnel 40, which is similar to the flared portion 32 of sleeve 19 (see FIGURE 9), and also serves as a guard means and lead-in.

FIGURE 3 shows as an additional detail a relatively flexible rupturable coating 42. This coating 42 normally

would be a dried or tacky rubbery adhesive which adheres to the shell fragments of the capsules 26 after crimping has ruptured the capsules 26 and released the liquid components 44 contained therein. This coating 42 can be advantageously employed in any of the embodiments.

FIGURE 4 illustrates how this invention can be inexpensively applied to low-cost pre-insulated solderless connectors. Note that sleeve 19b no longer serves as the capsule carrier means, that function being taken over by the tube 20b. FIGURE 5 illustrates how the low-cost connector in FIGURE 4 can be taper crimped to close the tube 20b around the wire 37 before the rupturing of the capsules 26 has occurred to any significant degree, thereby effectively closing off the rear of the connector 10b and forcing the liquid contact treating system 46 forward into the ferrule 14b. As a result the entire interior of the ferrule area is encapsulated with the now-mixed system (as shown in FIGURE 5, being most clearly shown, as cured epoxy 46, between the wire strands with the capsule fragments 26 remaining in the storage area).

FIGURES 6 and 7 show a sleeve 19c similar to that shown in FIGURES 8 and 9, except that in place of the barrel portion 22 and the groove portion 28 are legs 48 which neck down from the carrier portion 24c. These legs extend into the ferrule 14c and can extend therebeyond and be bent back as a wire stop 50 or as an anchor 52. The gaps between the legs serve the function of access holes 30 (see FIGURES 8 and 9).

The present invention can be fully discussed more easily by reference to the preferred embodiment illustrated in FIGURES 8 and 9 which particularly demonstrates the many advantages inherent in the present invention.

This preferred connector 10, see FIGURE 8, includes a standard crimp terminal 12 having a ferrule 14 and a tongue 16. The capsule carrier means 18 is adapted from a wire-insulation support sleeve 19, see FIGURE 9, and its insulation tubing 20. The plastic insulation tube 20 is similar to corresponding insulating tubes found in the many pre-insulated connectors known to the prior art, with the exception that tube 20 is closely fitted only to the barrel portion 22 at the ferrule-end of the sleeve 19 and is expanded to be radially spaced from the carrier portion 24 of the sleeve 19 thereby forming a storage area 25 for the capsules 26. The joined sleeve 19 and tube 20, forming the capsule carrier means 18, are advantageously clinched into position on said ferrule 14.

The sleeve 19 advantageously has a lead-in groove 28 spun into it between the barrel portion 22 and the carrier portion 24. This groove 28 also serves as a mixing chamber 33 for the liquid components of the system as they pass from separate storage within carrier means 18 out through the access holes 30 occurring in that side of the groove portion 28 which faces into the interior of ferrule 14. Furthermore, the presence of such a groove 28 greatly facilitates the formation of the access holes 30 by permitting use of a simple punch tool pushed longitudinally into the barrel portion 22, which tool can be as wide as said barrel portion. Otherwise, some type of radially acting tool might be required to work within these small spaces, which would have to be either very slender (and therefore fragile) or very complex. Note that lips 34, formed by punching out access holes 30, help to catch and hold back any of the capsule fragments which might break loose and would otherwise tend to block the access holes 30 or tend to pass through these holes and interfere with crimp-induced, cold-forged electrical contacts between the wire 36 and the metal ferrule 14. The formation of these lips 34 is one of the reasons for normally requiring the punching out of the access holes 30 from within the sleeve 19.

The end of sleeve 19 has a flared portion 32 shaped in the form of a bell-mouth to serve as an initial wire lead-in into the connector and more importantly to close off the end of the storage area 25 to protect the cap-

sules from injury before crimping and to prevent escape of the liquid components out the back of the connector during crimping. This latter advantage results in a neater, more efficient, connector which requires less bulk because all the liquid is forced through the access holes to the ferrule 14 where it belongs, rather than wastefully losing some out the rear of the connector where it might have collected on and soon jammed the crimping mechanism, contaminated the hands of the operator with the possibility of contact dermatitis, or contaminated adjacent mechanisms giving rise to possible malfunctions.

FIGURE 10 illustrates a slightly modified sleeve 19' which differs from that of FIGURES 8 and 9 only in the conformation of the lip 34' and the resulting access hole 30'. It will be noted that in this latter embodiment any loose shell fragments of the capsules 26 will tend to collect in the groove 28, with the liquid treating system 46 flowing over the skimming weir-like edge formed by lip 34' and into the access hole 30'.

The ability to apply capsules 26 to the outside of sleeve 19 advantageously by an adhesive 39 greatly increases the ease of assembly of the connector 10 and could actually result in a cut in costs rather than being an additional cost factor. This is especially significant because of the many additional advantages that sleeve 19, as shown in FIGURE 9 or 10, has. For example, as previously mentioned it completely protects the stored capsules from injury from without and from careless wire insertion prior to crimping. This sleeve 19 furthermore will give a support to the capsules 26 which causes them to break early in the crimp cycle, regardless of the size of the insulation 38, thereby squirting at least some of the mixed treating liquid between the ferrule 14 and the wire 36 prior to the actual meeting and cold forging of these two parts.

This earlier breaking of the capsules 26 to inject the treating liquid into the ferrule 14 during crimping, but prior to the formation of an effective crimp, might be termed "pre-encapsulation." Electrical contacts are formed by cold forging the ferrule and the wire together through the liquid, with the latter being squeezed out from each contact area, but remaining adjacent thereto, typically to harden there, and to protect the freshly made new-metal-to-metal contacts. The carrier 19 by backing up the capsules against the pressure of the crimping dies makes sure that nearly all of the liquid components are expelled from the storage area 25 out through the access holes 30. Thus, the capsules are ruptured at the same time and to the same extent regardless of the insulation thickness or the wire size; even if the wire 37 does not have any insulation 38 at all. This continued expulsion of liquid from the storage area 25 as the crimp proceeds, causes liquid to pool in the void between the ferrule 14 and the wire insulation 38 situated within the carrier portion 24. Within a few minutes the liquid in this pool travels by capillary action between the strands completing the encapsulation of the crimp by filling or sealing off any remaining minute voids present adjacent to the new electrical contact areas within the crimp. This capillary action may be thought of as a "post-encapsulation."

The length and tortuous route traveled by the liquid components along sleeve 19 to the interior of ferrule 14 and environs ensures that they adequately mix for proper curing or other co-action. The mixing chamber 33 and the squeezing action of the holes 30 on liquid components forced therethrough, further enhance this mixing.

The sleeve 19 with all these new advantages is still capable of serving as an excellent insulation support. Actually sleeve 19 is advantageously a little longer than the insulation supports of prior art connectors in order to provide an adequately large storage space 25 without having an unduly bulky connector, which latter would require extensive redesign of present crimp-tooling. This elongation of the sleeve 19 also results in increased sup-

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port for the insulation, especially since the tube 20 is still longer and is form-crimped around the insulation 38 beyond the sleeve 19, giving a flexible support to the wire and its insulation beyond the sleeve 19. This extra length of tube 20 beyond the sleeve 19 also prevents "flash-over" between adjacent connections or other nearby conductive materials.

The barrel portion 22 of said sleeve 19 is closely fitted over said ferrule 14, and may even be bonded thereto. This barrel portion 22 enables the terminal 12 to be advantageously made from flat copper stock without having to braze the resulting seam (not illustrated) in the ferrule. This naturally is a cost saving, and further, the seam acts as a channel for wicking curing epoxy, or other treating fluids, along the interior of the ferrule 14.

The tube 20, capable of transmitting crimp pressures, is made from insulating material of the type disclosed in W. S. Watts' Reissue Patent No. 23,688. This insulating material is the type employed in making pre-insulated solderless connectors. This, tube 20 must be capable of transmitting crimp pressures without tearing or shearing or otherwise impairing the integrity of the tube to an extent which might jeopardize its minimum insulating requirements.

Note that while all the illustrated embodiments of the present invention are pre-insulated connectors, one need not be so restricted in practicing the broader aspects of this invention. Furthermore, this invention is also applicable to solid and stranded wire, whether insulated or not, and therefore need not include an insulation support.

The capsules 26 serve to keep the reactive, or otherwise co-acting, liquid components of a treating system separate until the crimp formation of the connection. It is not required by this invention that all the components be liquid, nor that they all be stored in the capsules, nor that all of the components be stored separately. What is required is that the capsules be used to keep enough of the components separate to ensure that the system remains in its incipient state with no co-action occurring before crimping. Thus "components" as used in this specification will generally mean those parts of the treating system which must be kept separate during storage (except where another meaning is clearly intended, as in the foregoing portions of this paragraph). Some of the components could be stored in storage area 25 as a powdered solid or a thixotropic gel, etc., mixed in with capsules containing the other components. What is further required is that enough of the components be liquid enough so that, either through dissolving, or reaction, or the like, the released components upon crimping are effectively mixed and liquified into an effective treating system able to flow from the storage area to the area of treatment within the ferrule 14 and environs. However, it has been found that the most reliable results are obtained where the components (such as epoxy and its hardener) are all liquid and are all individually contained in a multiplicity of capsules.

Each capsule containing a given component should be in a distribution with the other components (contained in capsules or otherwise) such that upon rupture of the capsule, the first component almost immediately flows into contact with the other component to initiate mixing rapidly.

It has been found that a comparatively random distribution of capsules mixed in predetermined proportions generally give excellent mixing results upon crimping (e.g., see FIGURE 1). However, for improved customer acceptance (especially if tube 20 is translucent or transparent) and for consistent reliability, it has been found to be mechanically and economically feasible to arrange capsules 26 in annular rows (or similar ordered sequences or arrays) so that, for example in a two component system, a capsule 26a or 26c in one row which contains one component will always be next to a capsule

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26b or 26d in the next row which contains the other component (see FIGURE 8).

This invention may also be applied to connectors for non-electrical applications, such as on wires, cables, tubes, and like articles, whether metallic or not.

I claim:

1. A crimp-type electrical connector adapted to store a multi-component contact-treating liquid system which is activated by mixing, which connector comprises a metal ferrule adapted to be cold forged into electrical contacts with the stripped end of an insulated wire, a metal sleeve extending beyond one end of said ferrule adapted to be crimped into gripping relationship with the insulation of said wire thereby serving as an insulation support, pressure-rupturable capsules in a given distribution each containing a liquid component of said contact-treating system, a tube capable of transmitting crimp pressures made of deformable insulating material which circumferentially surrounds said ferrule and said sleeve and is closely fitted to the connector along a substantial portion of said ferrule while being radially spaced from said sleeve beyond said ferrule, said capsules being stored within the space between said sleeve and said tube, said sleeve having its free end flared to a bell-mouth to engage the tube and thereby closing off the end of the capsule space therebetween, said sleeve having access openings adjacent to said ferrule whereby upon crimping said capsules are ruptured with the liquids therefrom mixing and flowing through said access holes to the interior of said ferrule.

2. A connector as described in claim 1 wherein said sleeve fits over said ferrule and is there closely fitted by said insulating tube, the fitted tube and sleeve being fixed to said ferrule, said sleeve further having a groove rolled therein immediately adjacent to the end of said ferrule to serve as a wire lead-in to the ferrule and further to form a chamber together with said tube which serves to enhance the mixing of said liquid components during crimping, the side of said groove adjacent to the ferrule having holes punched therein to serve as said access openings.

3. A connector as described in claim 2 wherein each capsule is filled with a liquid component chosen from epoxy resin and hardener with the total number of capsules being generally distributed in appropriate proportions.

4. A connector as described in claim 3 wherein said capsules are securely anchored on said sleeve for ease of assembly and whereby upon rupturing substantially all of the fragments of said capsules are held on said sleeve.

5. A connector as described in claim 4 wherein said epoxy capsules and said hardener capsules are anchored on said sleeve in alternating annular rows whereby each capsule containing a given component has at least one capsule containing the other component immediately adjacent to it thereby ensuring more thorough mixing upon crimping.

6. A connector as described in claim 1 wherein said sleeve is fitted to said ferrule by a plurality of spaced legs which are necked down to extend into said ferrule.

7. A connector as described in claim 6 wherein at least one of said legs extends beyond said ferrule and is bent back thereon to anchor said sleeve to said ferrule.

8. A connector as described in claim 1 further comprising a leg portion of said sleeve extending within said ferrule away from said sleeve's flared end and bent substantially perpendicular to the ferrule opening to act as a wire-stop.

9. A connector as described in claim 1 wherein said capsules are positioned to require the tube over said storage space to be substantially larger than over said ferrule whereby said capsules stored within said space are preferentially ruptured prior to crimping of the ferrule.

10. A crimp-type electrical connector adapted to store a multi-component contact-treating liquid system which

is activated by mixing, which connector comprises a metal ferrule adapted to be cold forged into electrical contacts with a wire, pressure-rupturable capsules each filled with at least one liquid component of said contact-treating system and separately stored in distribution generally adjacent to said other components in a manner so that upon crimping the capsules are ruptured and the components are effectively mixed and flowed into said ferrule where said contacts are formed, and carrier means for storing said capsules therein at an area removed from said ferrule, said carrier means extending beyond one end of said ferrule in a generally cylindrical form, having flow access from said capsules to the interior of said ferrule, being adapted to be crimped onto a wire inserted within said connector and storing said capsules at an area subject to said crimping.

11. A connector as described in claim 10 wherein said carrier means comprises a tube capable of transmitting crimp pressures, which tube is made of insulating material and circumferentially surrounds and is mounted on said ferrule extending therebeyond at one end, said capsules being located within said tube in that portion whose area is removed from said ferrule.

12. A connector as described in claim 11 wherein a guard means is formed to fit within the free end of said tube for protecting said capsules from damage during wire insertion and for damming the free end of said tube during crimping thereby forcing the liquid components stored within said tube into the ferrule with the crimp-rupturing of said capsules.

13. A connector as described in claim 10, wherein said capsules include fracturable shells, which capsules are anchored within said carrier means, and wherein a relatively flexible rupturable coating is applied to said capsules to retain the fractured shell fragments of said capsules during crimping from entering said ferrule and interfering with the quality of the connection.

14. A connector as described in claim 10, wherein said carrier means comprises a metal support sleeve having a barrel portion closely fitting over said ferrule, a grooved portion adjacent to said barrel portion with access holes therein leading to said ferrule, said grooved portion adapted to serve as a wire lead-in to said ferrule, a carrier portion formed to receive therein any insulation of the wire to be crimped and adapted to store said capsules adhesively mounted thereon, and a flared portion, and further comprises a deformable insulation tube capable of transmitting crimp pressures which tube covers said sleeve being closely fitted to the barrel portion thereof and being expanded therebeyond to form an enclosed storage space for said capsules over said carrier portion of the sleeve, said flared portion adjoining the tube end thereby closing off the storage space.

15. A connector as described in claim 10 wherein said capsules are anchored on said carrier means, with the capsules in a set containing one given component occurring in ordered sequence and in appropriate propor-

tions with the capsules of the remaining sets, each of which remaining set contains the other components respectively, thereby ensuring close proximity of differing capsules resulting in more thorough mixing upon crimping.

16. A connector as described in claim 10 wherein said carrier means defines an enclosed storage area the inner cylindrical surface of which is substantially wider than said ferrule whereby said capsules stored in said carrier means are preferentially ruptured prior to crimping of the ferrule thereby forming a pre-encapsulated crimp-type connector.

17. A crimp-type connector adapted to store a multi-component liquid treating system which is activated by mixing, which connector is further adapted to be applied to a wire, cable, tube, and like articles, comprising a ferrule adapted to be crimped onto such an article, pressure rupturable capsules each filled with at least one liquid component of said treating system and separately stored in distribution generally adjacent to said other components in a manner such that upon crimping the capsules are ruptured and the components are effectively mixed and flowed into said ferrule to fill in and seal the resulting crimp connection occurring between said ferrule and said article placed therein, carrier means for storing said capsules therein at an area removed from said ferrule, said carrier means extending beyond one end of said ferrule in a generally cylindrical form, having flow access from said capsules to the interior of said ferrule, being adapted to be crimped onto an article inserted within said connector and storing said capsules at an area subject to said crimping.

18. A connector as described in claim 17 wherein said carrier means defines an enclosed storage area the interior cylindrical surface of which is substantially wider than said ferrule whereby said capsules stored in said carrier means are preferentially ruptured prior to the crimping of the ferrule thereby forming a pre-encapsulated crimp-type connector.

19. A connector as described in claim 17 wherein each capsule is filled with a liquid component chosen from epoxy resin and hardener with the total number of capsules being generally distributed in appropriate proportions.

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ALFRED S. TRASK, *Examiner*.