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(54) Compositions and methods for fabricating solvent resistant connectors.

(57) Compositions useful for fabricating grommets (36,116) of both the plug (30) and the receptacle inserts of a connector (10,100) resistant to solvents having a Shore A hardness of about 50 - 60 and about 65 - 75, respectively, comprises a mixture of halogenated (e.g. chlorinated) polyolefins and/or olefins, an activator, a release agent, a plasticizer, preferably a vulcanizer, preferably a cross-linking agent, optionally a filler, preferably a colorant or optionally a whitener. In addition, compositions useful for fabricating the socket (112) of the receptacle insert (108) of the connector resistant to solvents and with a Shore A hardness of about 65 - 75 comprises a mixture of halogenated (e.g. tetrafluoroethylene/propylene) olefins and/or olefins, an accelerator, a vulcanizer, a release agent, a processing aid agent, preferably a filler, preferably a colorant or optionally a whitener. Connectors are resistant to solvents commonly used in military and commercial aircraft operation when their grommets and sockets are fabricated from compositions as described above.

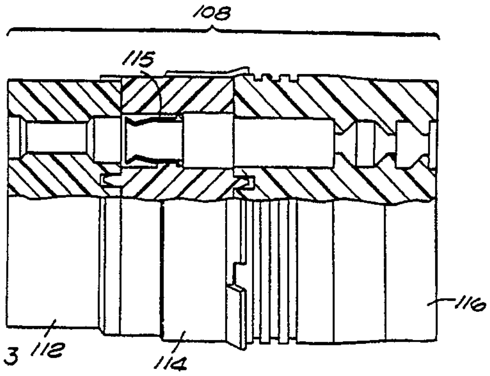

FIG. 3

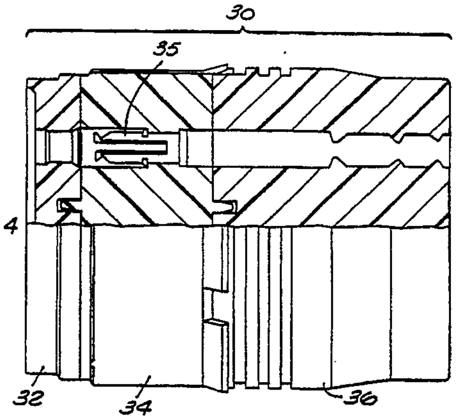

FIG. 4

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The present invention relates to chemical-stabile compositions useful for fabricating connectors resistant to solvents commonly used in aircraft operation in both military and commercial applications, connectors fabricated from such compositions, and processes used to fabricate such connectors.

Various kinds of fluids such as for example, hydraulic fluids, lubricating oils and the like are used in the aircraft industry. Such fluids may be based on products such as petroleum or may have a synthetic base. Concomitantly the chemical reactivity of the petroleum or synthetic based fluids with materials used to make connectors and the like must be resistant or substantially inert to the fluids that may come in contact with the connectors to ensure the connector will function properly and suitable for the purpose intended. The present aviation specifications approved for use by all departments and agencies of the U.S. Department of Defense for electrical connectors include requirements for environmental tests. More specifically, the present military standards require electrical connectors to be resistant to petroleum based aviation hydraulic fluids for use in temperatures -54° C to 135° C (65° F to 275° F) and synthetic based lubricating oils for aircraft turbine engines. Some commercial aviation specifications, however, require connectors to be resistant to synthetic based aviation hydraulic fluids.

As used herein, the term "military applications" is to be understood to include those aviation specifications requiring resistance to petroleum based aviation hydraulic fluids. The term "commercial applications," on the other hand, is understood to include those aviation specifications requiring resistance to synthetic based aviation hydraulic fluids.

As used herein, the term "connectors" means electrical connectors commonly used in the environment of aircraft operation and generally exposed to a variety of temperatures and corrosive solvents. Specifically, the connectors include those environment resisting, quick disconnect, miniature, circular electrical connectors and may contain hermetic receptacles.

The term "solvent" as used herein means solvents commonly used in aircraft operation, in both military and commercial applications. The term "solvent" is also understood to mean herein.

As used herein, the word "resistant" as used with reference to compositions and connectors means the ability to resist swelling when subjected to solvent under the Solvent Resistant Test described below.

Specifically, the compositions and connectors are resistant to hydraulic fluids having a petroleum base as well as aviation hydraulic fluids having a synthetic phosphate ester base. Additionally the connectors must be resistant to fluids encountered in jet aircraft operation including, inter alia, aircraft turbine engine lubricating oils having a synthetic base. The purpose of the test is to identify compositions and connectors having durable and lasting resistance to those solvents normally used in aircraft operation that causes swelling to the connectors and prevent it from proper functioning.

Electrical connectors and their coupling assemblies find wide use in military and commercial applications. Such connectors are designed to operate in extreme environmental conditions such as extreme temperature and a variety of corrosive solvents used in high altitude flight. The connectors are sealed to withstand such conditions as moisture condensation, corona, flashover and vibrations, providing a completely environmentally resistant assembly when the connector's plug and receptacle assembly halves are mated.

In the past, different compositions of material were needed to fabricate connectors separately for military and commercial applications. For example, the whole gasket or insert of the connector for military applications was made of neoprene rubber, but butyl rubber was used for commercial applications. These dual compositions were necessary because neoprene rubber connectors react with phosphate ester synthetic hydraulic fluids used in some commercial applications during the solvent resistant test. On the other hand, connectors fabricated from butyl rubber suffer severe swelling damage and leakage when immersed in petroleum based hydraulic fluids and some synthetic lubricating oils conforming to other specifications while remaining inert to the synthetic fluid. One such phosphate ester synthetic aviation hydraulic fluid is SKYDROL™ Hydraulic Fluid No. 500B, available from Monsanto Chemical Corp.

Thus, there is a continuous and urgent need for a single connector of solvent resistant compositions that can be used in both types of applications.

Moreover, a need also exists for solvent resistant compositions that are easily formable, simple to demold after processing, economical and non-toxic for fabricating such connectors in aircraft operations.

The present invention provides chemical-stabile compositions useful for fabricating connectors resistant to solvents commonly used in aircraft operation in both military and commercial applications.

The present invention specifically provides chemical-stabile compositions useful for fabricating connectors resistant to hydraulic fluids having either a petroleum or synthetic base and lubricating oils having either petroleum or synthetic base.

The present invention provides compositions useful for fabricating the grommets of both the plug and the receptacle inserts of the connector resistant to solvents and has a Shore A hardness of about 50-60 wherein the composition comprises a mixture of halogenated polyolefins and/or olefins, and activator, a release agent, a plasticizer, preferably a vulcanizer, preferably a cross-linking agent, preferably a filler, preferably a colorant or optionally a whitener.

The present invention also provides novel compositions useful for fabricating the socket of the plug insert of the connector, resistant to solvents and with a Shore A hardness of about 65-75 wherein the composition comprises a mixture of halogenated polyolefins and/or olefins, an activator, a release agent, a plasticizer, a vulcanizer, a cross-linking agent, preferably a filler, preferably a colorant or optionally a whitener.

In addition, the present invention also provides novel compositions useful for fabricating the socket of the receptacle insert of the connector resistant to solvents and with a Shore A hardness of about 65-75 wherein the composition comprises a mixture of halogenated olefins and/or olefins, an accelerator, a vulcanizer, a release agent, a processing aid agent, preferably a filler, preferably a colorant or optionally a whitener.

The present invention further provides connectors resistant to solvents commonly used in military and commercial aircraft operation, wherein the compositions of the grommets and sockets of the connectors are as described above.

Moreover, the present invention provides a method of fabricating connectors as described above, wherein during the fabricating process, the material does not stick to the mold. Also having good hot tear-strength, the demolding capability of this material is outstanding.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, wherein similar characters refer to similar elements throughout and in which:

FIGURE 1 is a partial cutaway side view of a practical embodiment of a wall-mount, front release receptacle shell of a solvent resistant connector;

FIGURE 2 is a partial cutaway side view of a practical embodiment of a connector plug to be mated with the receptacle shell as shown in Figure 1;

FIGURE 3 is a cross-sectional view of a socket insert assembly used in the receptacle shell of Figure 1; and

FIGURE 4 is a cross-sectional view of a pin insert assembly used in the plug assembly of Figure 2.

The components of environment resisting, quick disconnect, miniature, circular electrical connectors are well-known, such as those for example disclosed in U.S. Patent No. 3,808,580 to Johnson. Figures 1 and 2 show a connector assembly which are used in both military and commercial applications. The connector assembly comprises a plug assembly 10 and a receptacle shell 100 that is coupled and disengaged by twisting the plug assembly 10 along a helical pathway X around the receptacle shell 100 by means of a coupling system, preferably of the bayonet type or which can be of the threaded type. The receptacle shell 100 is integral with a receptacle plate 102 for mounting on an instrument control panel or other wall mounting. Three fixed bayonet pins 104 extend radially outward from the outer surface 106 of the receptacle shell 100. A receptacle insert assembly 108 is then bonded to the receptacle shell 100. The bonding can be performed by any conventional method, but preferably by means of epoxy bonding.

Similarly, the plug assembly 10 is provided with a coupling nut subassembly 11 on the front and a plug insert assembly 30 is bonded to the plug assembly 10. To assure proper orientation for mating, the connector plug shell 10 is polarized to align in a preferred orientation within the inner surface of the receptacle shell 100 as shown in Figures 1 and 2. Referring now to Figures 1 and 3, the receptacle insert 108 is shown to have a 3-ply sandwich construction with a socket front insulator 112, a center hard dielectric insert subassembly socket 114 with contact retaining clip 115 and a back resilient grommet 116 and strain relief clamp (not shown).

The socket front insulator 112 is shown to have socket contact 118 positioned in the front end thereof. The front end of the socket contact extends forward from the front surface of the inner resilient insert. A conductor 120, which normally is soldered or crimped to the socket 118, extends rearwardly in the insulator 112. While only one socket contact 118 and one conductor 120 are shown, it should be understood, of course, that a plurality of sockets and associated conductors are normally mounted in the insulator 112.

Referring now specifically to Figures 2 and 4, the plug insert 30 adapted to be mated with the receptacle insert 108 is shown to have a similar 3-ply sandwich construction with a pin front insulator 32, a center hard dielectric pin insert subassembly 34 with contact retaining clip 35 and a back resilient grommet 36. The pin front insulator 32 is shown to have a pin contact 38 at the front end with a forwardly extending portion adapted to be mated with the socket contact 118. A conductor 40, which may be soldered or crimped to the pin contact 38, is positioned in the rear of the pin front insulator 34.

When the plug and receptacle of the connector of Figures 3 and 4 respectively are mated by the coupling system, the pin contact 38 is inserted in the socket contact 118. In addition, the receptacle shell

100 is positioned between the outer surface of the plug assembly 10 and the coupling nut subassembly 11. The coupling nut 11 is rotated so that the apertures engage the bayonet pins 104 in the outer surface of the receptacle shell 100.

In the present invention, it has been found that a specific combination of compositions is required to fabricate the grommets and sockets of the inserts of the electrical connector so as to function properly and resist solvents commonly used in aircraft operations in both military and commercial applications.

The same composition is used for both the grommets of the insert for the receptacle shell and the plug assembly of the connector.

The halogenated polyolefins used in the grommet composition may be of any type, but is preferably of the non-reactive type and preferably has, as halogens, chlorine. Exemplary halogenated polyolefin compounds include TYRINETM chlorinated polyethylene elastomers, such as TYRINETM 566 sold by the Dow Chemical Company, Specialty Plastics Department, Midland, Michigan. The halogenated polyolefins may be used alone in the composition or as a mixture with other compounds, such as a different halogenated polyolefin or olefins.

Olefins used in the grommet composition can be of any type, but is preferably of the ethylene-propylene type, such as the commercially available DPSYN 40A base rubber terpolymer sold by Copolymer Rubber Corporation, Baton Rouge, Louisiana.

A variety of activators/stabilizers, appropriate to promote and stabilize the curing of the present grommet compositions may be used. Such activators/stabilizers include lead oxide, sold as T(HRL) D90 available commercially from Rhein Chemi, Trenton, New Jersey. Other lead compounds, such as basic silicate of white lead, litharge, and red lead, and magnesium oxide or hydroxide may be used.

For many applications, the grommet compositions are preferably filled, and more preferably contain loadings of about 30-100 parts of filler per hundred parts of halogenated polyolefin/olefin mixtures. The filler may comprise one or more of the several conventional fillers such as clays, calcium carbonates, and silicas. Especially preferred are filled grommet compositions wherein the filler is predominantly mistron vapor (MV TALC), a magnesium silicate filler sold by Cyprus Industrial Minerals Corporation, Englewood, Colorado. Other fillers are preferably employed in lesser amounts in combination with MV TALC as the filler.

Many of the grommet compositions of the present invention also contain a colorant such as carbon black, pigments, dyes and the like. Colorants such as red or yellow iron oxide are preferable.

Many of the present grommet compositions also may include a cross-linking or vulcanization agent, and especially commercial peroxides including dicumyl peroxide, α,α-bis (t-butyl peroxy), di-isopropyl benzene, and butyl-4-4-bis (t-butyl peroxy) valerate. A co-agent such as triallyl trimellitate, triallylcyanurate, triallylisocyanurate and trimethylolpropane trimethylacrylate, is preferably being used with the peroxide to improve modulus, to increase the rate of curing, and to increase crosslinking density.

The plasticizers used in the grommet composition may be of any type, but is preferably of the liquid plasticization materials common to the rubber industry including esters, epoxidized soybean oils and chlorinated paraffins. Exemplary of plasticizers are di-isonono phthalate, di-ethylhexyl adipate or the like.

Mold release agents (that is, lubricants) are generally included in the grommet compositions of the present invention. Exemplary are carnauba wax, montanic acid ester wax, polyethylene wax, polytetrafluoroethylene wax, glycerol monostearate, calcium, zinc and other metallic stearates, paraffin waxes and the like.

Grommet compositions of the present invention may be prepared by any conventional method. For example, the ingredients may be readily processed either in internal mixers of the Banbury type or on two-roll mills. Preferably, Banbury mixing with an up-side down mixing procedure is used. More generally, the ingredients (or any portion of them) may be prepared in a dry, discrete-particle, crumb form, fed directly into a compounding devices such as an extruder or prepared as a premix of raw materials. If less than all of the ingredients are present in the initial form, the remainder of the ingredients can be added prior to or during densification. Densification can be by mechanical compacting (with, for example, a performer or a combining mill) in the case of a fine powder, and can be an extruder or differential roll mill in the case of fine powders, direct feed or premix. These compositions may be molded into various connectors by application of the requisite temperature and pressure. For example, molding conditions for the connector grommet of the present invention may range from about 300-400° F, for a total cycle time, including cure time, injection time and cleaning time, ranging from about 1-20 minutes, preferably 2-15 minutes depending on the size of the connector to be molded. Any suitable molding apparatus may be employed, such as a compression or injection molding machine equipped with the appropriate mold.

The ratio between the various ingredients may vary widely. In the following disclosure, unless otherwise stated, all parts by weight of the ingredients are in reference to the total weight of the halogenated polyolefin/olefin elastomer component (i.e. the total weight of the halogenated polyolefin/olefin is taken to by

100 parts by weight) used in the composition. In general, the ratio of the weight of the halogenated polyolefin to the weight of the olefin used will be between about 3 - 7, preferably between about 3.5 - 5.

Whatever activators/stabilizers are employed, are generally applied at levels sufficient to provide processing stability and improve long-term high heat exposure of the grommet molding composition under anticipated molding conditions. Generally, amounts between about 25 - 35 parts by weight are sufficient, preferably about 30 parts by weight.

The total amount of filler used may vary from 0 up to about 50 parts by weight. Preferably, the filler comprises a total of between about 20 - 45 parts by weight and preferably between about 30 - 40 parts by weight. Also, preferably, between about 30 - 40 parts by weight in reference to the total elastomer components is a silica filler such as MV TALC.

Colorants, if employed, are generally in amounts sufficient to give connectors the desired color which in many cases is brown.

Whatever cross-linking or vulcanization agent is generally applied at levels sufficient to cross-link or vulcanize the grommet molding composition under anticipated molding conditions. Usually amount between about 1 - 10 parts by weight. Preferably, the cross-linking or vulcanization agent is applied at about 2 - 5 parts by weight.

The plasticizer used is generally in an amount sufficient to give the desired plasticizing efficiency and performance under anticipated molding conditions. Usually amounts between about 35 - 70 parts by weight are sufficient. Preferably, the plasticizer is applied at about 45 - 65 parts by weight.

The mold release agent will be used in amounts sufficient to give good release from the mold. Lubricant proportions between about 5 - 15 parts by weight, preferably between about 8 - 12 parts by weight, can be employed.

A composition similar to that used in the grommets of both the receptacle shell insert and the plug assembly insert of the connector is used for the pin front insulator of the plug assembly insert. The critical difference is that a lower parts by weight, preferably less than 30 parts, of plasticizer is used in the pin front insulator composition so that the pin front insulator of the plug assembly insert has a hardness of 70 Shore A for better mating with the socket front insulator of the receptacle insert.

The present invention also relates to compositions useful for fabricating the socket front insulator of the receptacle insert for the connectors resistant to solvents commonly used in aircraft operation in both military and commercial applications.

The halogenated polyolefin/olefin copolymer used in the composition of the socket front insulator of the receptacle insert may be of any type, but is preferably of the non-reactive type and preferably the polyolefin has, as halogens, fluorine. Exemplary halogenated polyolefin/olefin copolymers include the AFLAS™ FA 100S or FA150E sold by the 3M Industrial Chemical Products Division, St. Paul, Minnesota. The halogenated polyolefins/olefin copolymer may be used alone in the composition or as a mixture with other compounds, such as another halogenated polyolefin/olefin copolymer.

Olefins used in the composition of the socket front insulator of the receptacle insert can be of any type, but is preferably of the ethylene propylene type, such as the commercially available TRILENE™ 65 base liquid polymer sold by Uniroyal Chemical Division of Uniroyal Incorporated, Nanagatuck, Connecticut.

A variety of cross-linking or vulcanization agents appropriate to promote and stabilize the curing of the compositions of the present socket front insulator of the receptacle insert may be used. Such cross-linking or vulcanization agents include commercial peroxides such as dicumyl peroxide, α,α-bis (t-butyl peroxy) diisopropyl benzene, and butyl-4-4-bis (t-butyl peroxy) valerate. Preferably, a butylperoxy vulcanizer is used.

A co-agent such as triallyltrimellitate, triallylcyanurate, triallylisocyanurate and trimethylolpropane trimethylacrylate, is preferably being used with the peroxide to improve modulus, to increase the rate of curing, and to increase cross-linking density. Most preferably, a triallyl isocyanurate co-agent is used.

For many applications, the compositions of the socket front insulator of the receptacle insert are preferably filled, and more preferably contain loadings of about 20 - 45 parts of filler per hundred parts of halogenated polyolefin/olefin mixtures. The filler may comprise one or more of the several conventional fillers such as clays, calcium carbonates and silicas. Especially preferred are filled socket compositions wherein the filler is predominant a fumed silica filler sold commercially as MIN-U-SIL™ 5 Micro available from Summit Chemical, Akron, Ohio.

Many of the compositions for the socket front insulator of the receptacle insert of the present invention also contain a colorant such as carbon black, pigments, dyes and the like. Colorants such as red or yellow iron oxide are preferable.

Mold release agents or lubricants are generally included in the compositions for the socket front insulator of the receptacle insert of the present invention. Exemplary are carnauba wax, montanic acid ester wax, polyethylene wax, polytetrafluoroethylene wax, glycerol monostearate, calcium, zinc and other metallic stearates, paraffin waxes and the like.

A processing aid/dispersing agent such as low molecular weight olefinic oil sold commercially as SPAN-60TM available from Emulsion Engineering, Wilmington, Delaware and DYNAMARTM PPA-790 available from 3M Industrial Chemical, Products Division can be added to the compositions for the socket front insulator of the receptacle insert to improve flow rates for extrusion or molding applications.

Compositions for the socket front insulator of the receptacle insert of the present invention may be prepared by any conventional method. For example, the ingredients may be readily processed like any other rubber part by compression, transfer or injection molding. Compositions are mixed on open mills or internal mixers. More generally, the ingredients (or any portion of them) may be prepared in a dry, discrete-particle, crumb form, fed directly into a compounding devices such as an extruder or prepared as a premix of raw materials. If less than all of the ingredients are present in the initial form, the remainder of the ingredients can be added prior to or during densification. Densification can be by mechanical compacting (with for example a performer or a combining mill) in the case of a fine powder, and can be by an extruder or differential roll mill in the case of fine powders, direct feed or premix. These compositions may be molded into various socket front insulators of the receptacle insert by application of the requisite temperature and pressure. For example, molding conditions for the connector socket front insulator of the receptacle insert of the present invention may range from about 300 - 450° F, preferably about 340 - 360°, for a total cycle time ranging from about 1 - 20 minutes, preferably 2 - 15 minutes, depending upon the size of the connector to be molded. Any suitable molding apparatus may be employed, such as a compression or injection molding machine equipped with the appropriate mold.

The ratio between the various ingredients may vary widely. Preferably, a mixture of halogenated polyolefin is used such as AFLASTM FA100S and F150E available from 3M Industrial Chemical Products Division. The ratio of FA100S to FA150E used may range from about 0.2 - 2, preferably from about 0.7 - 1.5. In general, the weight of the total halogenated polyolefin to the weight of the olefin used will be between about 5 and 25, preferably between about 10 - 20.

Whatever activators, stabilizers are employed are generally applied at levels sufficient to provide processing stability and improve long-term high heat exposure of the socket molding composition under anticipated molding conditions. Generally, amounts between about 0.1 - 10 parts by weight are sufficient.

The total amount of filler used may vary from 0 up to about 50 parts by weight. Preferably, the filler comprises a total of between about 20 - 45 parts by weight. Also, preferably, between about 20 - 35 parts by weight is a fumed silica filler.

Colorants, if employed, are generally in amounts sufficient to give connectors the desired color which in many cases is brown.

Whatever cross-linking or vulcanization agent is used is generally applied at levels sufficient to cross-link or vulcanize the socket molding composition under anticipated molding conditions, usually an amount between about 1 - 10 parts by weight. Preferably, the cross-linking or vulcanization agent is applied at about 2 - 5 parts by weight.

The processing aid used is generally in an amount sufficient to give the desired flow rates for extrusion and performance under anticipated molding conditions. Usually amounts between about 0.1 - 5 parts by weight are sufficient.

The mold release agent will be used in amounts sufficient to give good release from the mold. Lubricant proportions between about 0.1 - 10 parts by weight, preferably between about 0.5 - 2.5 parts by weight, are employed.

The present invention is not restricted to the above ingredients but may include other ingredients which do not detract from solvent resistant properties of the compositions of the grommets and sockets of the plug and receptacle inserts of the connector. Accordingly, other halogenated polyolefins, olefins, organic or inorganic materials or the like may be added under the above conditions.

The following non-limiting examples further illustrate the present invention. All parts are by weight in reference to the total weight of the halogenated polyolefin/olefin elastomer used in the composition unless otherwise indicated.

The "solvent resistant test" referred to in the following examples of method 2013 of MIL-STD-1344 wherein the connectors the mating numbers are mounted to appropriate fixtures that hold the connector members in their normal manner, the fixtures being movable such that the members may be mated and unmated at a specific rate of movement. The mating members are then brought to a position where mechanical mating begins. The force or torque gage is set at 0, the mating connector members are fully mated at the rate specified and the force recorded. The force is again measured as the connector members are unmated at the specified rate. Samples of the unmated connectors are then immersed fully in the respective fluids specified below for 20 hours as required by the specification. The immersion is followed by a one hour drain (air dry at room temperature) and the mating and unmating forces of the plug and receptacle of the connector that had been immersed simultaneously in the fluids tested are then measured again. If the connector's mating and unmating forces fall within the forces as specified, the connector is considered solvent resistant within the meaning of the term as used herein.

EXAMPLES 1-9

Grommets compositions for both the plug and the receptacle inserts were prepared from the formulations indicated in Table 1. Formulation 1 is a starting formulation and has molding difficulties due to the absence of a plasticizer, TYRINETM 566 available from Dow Chemical Company. A different type of chlorinated-polyolefin other than TYRINETM 136 is used in Formulation 2. Ethylene-propylene copolymer is added in formulation 3 to improve its chemical resistance. In formulation 4, an internal lubricant is added to improve its flow characteristics during molding. Pigment is added to formulation 5 to give the desired color. In formulation 6, internal lubricant concentration is increased, but ethylene-propylene copolymer concentration decreased. Formulation 6 gives a good compression molding composition. In formulations 7 and 8, the filler MV TALC was replaced by HISIL-233 available from PPG Industries, Chemical Division, Pittsburgh, Pennsylvania, and the amounts of plasticizer increased to 50 and 63 parts, respectively. Formulation 9 gives the best grommet injection molding composition.

Formulation 9 is selected as molding material for fabricating the grommets for both the plug and the receptacle inserts. In particular, the formulation is compression or injection molded at a temperature of 350° ± 5° and a total cycle time of 2 - 15 minutes depending upon the size of the connector to be molded. The molded grommets have a Shore A hardness of 55.

TABLE 1

		1	2	3	4	5	6	7	8	9
Polyolefin	TYRINE CM0136[a]	80								
	TYRINE 556[b]		100	80	80	80	100	95	95	100
Olefin	EPSYN 40A[c]	20		20	20	20	15	20	25	15
Activator	T(HRL) D-90[d]		45	45	45	45	30	30	30	30
	MAG-LITE-D[e]	5								
Filler	ATOMITE[f]	100								
	TOTM[g]	50								
	MV TALC[h]		40	60	60	60	35	20		
	HISIL-210[j]	10								
	HISIL-233[j]							15	37	35
Vulcanizer	VULCUP 40KE[k]	5	5	5	5	6	6	6	6	6
Cross-linking agent	TATM[l]		4	4	4	4	4	4	4	4
Plasticizer	DINP[m]		40	50	50	40	40	50	63	63
Whitener	A-410[n]	3								
Colorant	Red oxide[o]					12	12	12	12	12
	Yellow oxide[o]					5	5	5	5	5
	N-762[q]									
Release agent	MC Blend 9222				4	4	10	10	10	10

The identity or grade of these ingredients is as follows:

[a]TYRINE 0136 chlorinated polyethylene - based rubber (Dow)
[b]TYRINE 566 chlorinated polyethylene - base rubber (low modulus) (Dow)
[c]EPSYN 40 A ethylene propylene - base rubber terpolymer (Copolymer Rubber Corp.)
[d]T(HRL) D90 lead oxide 90% dispersed
[e]MAG LITE-D magnesium oxide (C.P. Hall Co., Chicago, Illinois)
[f]ATOMITE calcium carbonate (Thompson Weinman & Co., Cartersville, GA)
[g]TOM t-octylmercaptan (Pennualt Corporation, Philadelphia, PA)
[h]MV Talc magnesium silicate (Cyprus)
[i]HISIL-210 amorphous silica (PPG)
[j]HISIL-233 amorphous silica (PPG)
[k]VULCUP 40KE butylperoxy (Hercules Inc., Wilmington, DE)
[l]TATM triallyl trimellitate (Wyrouger and Loser)
[m]DINP di-isonono phthalate (C.P. Hall)

[n]A-410	titanium dioxide (N.J.Zinc, Palmerton, PA)
[o]Red iron oxide	color pigment (C.P. Hall)
[p]Yellow iron oxide	color pigment (C.P. Hall)
[q]N-762 carbon black	color pigment (DeGussa, Inc., New York, NY)
[r]MC Blend 9222	internal release agent, silicone based (Mach-1 Compounding, Macodonia, OH)

EXAMPLES 10-15

Preferred socket compositions for the insert of the plug with a Shore A hardness of 70 were prepared from the formulations indicated in Table 2.

TABLE 2

CPE COMPOUND 70 SHORE A

		10	11	12	13	14	15
Polyolefin	TYRINE CM0136[a]	80	80				
	TYRINE 566[b]			100	80	80	80
Olefin	EPSYN 40A[c]	20	20		20	20	20
Activator	T(HRL) D-90[d]			45	45	45	45
	MAG LITE-D[e]	5	5				
Filler	ATOMITE[f]	100	100				
	TOTM[g]	19	30				
	MV TALC[h]			60	60	60	60
	HISIL-210[i]		10				
	HISIL-233[j]	10					
Vulcanizer	VULCUP 40KE[k]	5	5	5	5	6	6
Crosslinking agent	TATM[l]			4	4	4	4
	CHEMLINK 30LSW2[l1]	5	5				
Plasticizer	DINP[m]				15	20	25
	DOA[m1]	19					
Whitener	A-410[n]	3	3				
Colorant	Red oxide[o]					12	12
	Yellow oxide[p]					5	5
	N-762[q]					3	3
Release agent	MC Blend 9222[r]					4	8
	Paraffin wax[r1]			2			
Anti-oxidant	IRGANOX HG90[s]	2					
	WB212[s1]				2		

[l1] CHEMLINK (Sartomer Co., West Chester, PA)

[M1] DOA Diethylhexyl adipate (Hardwicke Chemical Co., Elgin, SC)

[R1] paraffin wax

[s] IRGANOX HG90 (Ciba-Geigy Corp., Ardsley, NY)

[s1] WB212 petroleum oil (Struktol Co., Stow, OH)

Formulation 10 is a starting socket formulation for the plug insert and has molding difficulties. In formulation 11, more plasticizer was added and a finer type of filler is used to improve the flow of the formulation. A different type of chlorinated polyethylene is used in formulation 12 to improve the physical properties of the compositions during the molding process. In formulation 13, ethylene-propylene copolymer is added to the composition in order to obtain better chemical resistance. In formulations 14 and 15, pigments were added to give formulation a dark brown color, internal lubricant and plasticizer were added for better release and flow properties of the composition during molding.

Formulation 15 is selected as molding material for fabricating the socket of the insert of the plug assembly. In particular, the formulation is compression molded at a temperature of 350° ± 5° F and for a total cycle time of 2-15 minutes depending upon the size of the connector to be molded. The molded socket of the insert of the plug assembly has a Shore A hardness from about 65 to about 75.

EXAMPLES 16-21

Socket compositions for the insert of the receptacle shell having a Shore A hardness of 70 were prepared from formulation indicated in Table 3.

TABLE 3

FLUOROELASTOMER COMPOUND 70 SHORE A

		16	17	18	19	20	21
Fluoroolefin	FA-150P medium viscosity^{t}					94	
	FA-100S high viscosity^{u}	40	44	44	44		54
	FA-150E low viscosity^{v}	50	50	50	50		60
Olefin	TRILENE 65^{w}	10	6	6	6	6	6
Accelerator	TAIC^{x}	3	3	3	3	3	3
Filler	AUSTIN BLACK^{y}		10	10	10	10	10
	MIN-U-SIL 5N^{z}		25	24	24	24	24
Vulcanizer	LUPERCO 101XL^{aa}	3	3	3	3	3	3
Release agent	SPAN 60^{bb}	1	1	1	1	1	1
	Carnauba wax^{cc}	1		2	2	2	2
Processing aid	DYNAMAR PPA-790^{dd}		1				
Whitener	A-410 (TiO_2)^{ee}				3	3	3
Colorant	Red iron oxide^{o}				6	6	6
	Yellow iron oxide^{p}				3	3	3
	N-762^{q}				.5	.5	.5
	Mapico Tan 10^{ff}	15					
	Mapico Brown 420^{gg}		1				

The identity or grade of the ingredients is as follows:

^{t} FA-150P(AFLAS)	tetrafluoroethylene/propylene - base rubber (medium viscosity) (3M)
^{u} FA-100S(AFLAS)	tetrafluoroethylene/propylene - base rubber (high viscosity) (3M)
^{w} TRILENE 65	liquid ethylene propylene - improve chemical resistance and viscosity (Uniroyal)
^{y} AUSTIN BLACK	carbon black - filler (Hardwicke Chemical)
^{x} TAIC	triallyl isocyanurate
^{z} MIN-U-SIL	fumed silica - filler (Summit)
^{aa} Luperco 101XL	butyl peroxy (Hardwicke Chemical)
^{bb} SPAN 60	low molecular weight olefinic oil (Emulsion Engineering)
^{cc} Carnauba wax	wax
^{dd} DYNAMAR PPA-790	low molecular weight olefinic oil (3M)
^{ee} A-410 TiO_2	white pigment (Harcross Chemical)
^{ff} Mapico Tan 10	tan pigment (Columbian Chemical Corp., Atlanta, GA)
^{gg} Mapico Brown 420	brown pigment (Columbian Chemical Corp.)

Formulations 16-21 contain a fluoroelastomer instead of the chlorinated elastomers as in formulations 10-15. Formulation 16 is a basic formulation and has a low Shore A hardness. Formulation 17 gives a Shore A hardness of 70 but the composition stick to the mold during processing. In formulation 18, 2 parts by weight of an internal release agent is added to improve its mold release and flow properties. Dark brown pigment was added to formulation 19 to give its desirable color, but the composition has flow problem during processing. Formulation 20 uses a high strength, medium viscosity fluoroelastomer, but its hot tear properties are inferior. Formulation 21 uses a combination of the fluoroelastomer FA-100S and FA-100E give the best hot tear and molding properties, particularly for compression molding.

Formulation 21 is selected as molding material for fabricating the socket of the insert of the receptacle shell. In particular, the formulation is compression molded at a temperature of 350° ± 5° F for a total cycle time of 2-15 minutes depending upon the size of the connector to be molded. The molded socket of the insert of the receptacle shell has a Shore A hardness of about 70.

Completed connectors were fabricated with plug assemblies and receptacle shells using molded components from formulations 9, 15 and 21 and corresponding connector parts. Four groups of identical connectors, a set of each shell sizes of 10 and 24 meeting Series 1, Class E of military and commercial physical specifications were assembled. These connectors were then subjected to the solvent resistance test. The results are shown in Table 4. Table 4 also gives the maximum force permitted by the various specifications.

TABLE 4

Coupling/Uncoupling performance results of connector assembly subjected to the solvent resistance test

Group No.	Shell Size	Spec. (Max)	Torque in in/lb before test Coupling	Uncoupling	Spec.	Torque in in/lb after test Coupling	Uncoupling
I[hh]	10	12±1	4.2	6.5			
	24	44.0±7	14.2	22.7			
II[ii]	10				12±1	3.8	5.7
	24				44±7.0	12.5	18.9
III[jj]	10				12±1	3.5	3.8
	24				44±7	12.7	14.3
IV[kk]	10	12±1	3.9	5.1	12±1	3.2	4.6
	24	44.0±7	15.8	23.6	44±7	12.5	19.8

hh control group, no solvent resistance test performed

ii solvent resistance test is performed with aircraft turbine engine synthetic base

jj solvent resistance test is performed with petroleum base hydraulic fluid suitable for use from -54°C to 135°C (-65°F to 275°F).

kk solvent resistance test is performed with fluid Monsanto SKYDROL™ Hydraulic Fluid 500B, a phosphate ester synthetic aviation hydraulic fluid

Coupling/uncoupling performance test results for control Group I and test Group IV prior to the solvent resistance test are almost identical, supporting the consistency of the connector assemblies fabricated in the present invention. As shown in Table 4, after the connectors (Group II-IV of both shell size 10 and 24) were subjected to the solvent resistance test, there is little change in their coupling/uncoupling performance and in all cases, both the coupling/uncoupling performance of the connector, before and after the solvent resistance test, all met and exceed the military and commercial performance specifications. Accordingly, all connectors shown in Table 4 passed the solvent resistance test.

The foregoing examples are intended to illustrate, without limitation, the chemical-stabile composition of the present invention, their preparation and use for fabricating connectors resistant to solvents commonly used in aircraft operation in both military and commercial applications. It is understood that changes and variations can be made therein without departing from the scope of the invention as defined in the following claims.

Claims

1. An electrical connector resistant to solvents comprising:
   (A) a cylindrical receptacle shell 100 having a receptacle insert 108 bonded thereto, the receptacle insert 108 including a socket front insulator 112, a center insert subassembly 114 bonded to the front insulator and a back grommet 116 bonded to the center subassembly 114 at the opposite end from the socket front insulator 112; and a connector plug assembly including a connector shell 10 having a plug insert 30 bonded thereto, the plug insert 30 including a pin front insulator 32, a center insert subassembly 34 bonded to the pin front insulator 32 and a back grommet 36 bonded to the center insert subassembly 34 at the opposite end from the pin front insulator 32, said connector being characterized in that:
   the socket front insulator 112 is fabricated from a mixture comprising:
   (a) about 80-150 parts by weight of a halogenated elastomer;
   (b) an effective amount of an activator to provide processing and long term heat stability in an amount of from about 0.1-10 parts by weight;
   (c) between about 20-45 parts by weight of compound of a filler;
   (d) an effective amount of a mold release agent for the release of the cured molding composition from a mold in an amount of from about 0.5-10 parts by weight;
   (e) an effective amount of a vulcanization agent sufficient to vulcanize the composition under molding conditions in an amount of from about 1-10 parts by weight;
   the pin front insulator 32 is fabricated from a mixture comprising:
   (a) about 70-130 parts by weight of a halogenated elastomer;
   (b) an effective amount of an activator to provide processing and long term heat stability in an amount of from about 35-55 parts by weight;
   (c) between about 40-80 parts by weight of compound of a filler;
   (d) an effective amount of a plasticizer to give the desired plasticizing efficiency and performance under molding conditions in an amount of from about 5-40;
   (e) an effective amount of a mold release agent for the release of the cured molding composition from a mold in an amount of from about 2-12 parts by weight;
   (f) an effective amount of a cross-linking agent sufficient to cross-link the composition under molding conditions in an amount of from about 1-10 parts by weight; and
   (g) an effective amount of a vulcanization agent sufficient to vulcanize the composition under molding conditions in an amount of from about 1-10 parts by weight; and
   the back grommets 116,36 of both the receptacle and plug inserts are fabricated from a mixture comprising:
   (a) about 70-130 parts by weight of a halogenated elastomer;
   (b) an effective amount of an activator to provide processing and long term heat stability in an amount of from about 25-35 parts by weight;
   (c) between about 20-45 parts by weight of compound of a filler;
   (d) an effective amount of a plasticizer to give the desired plasticizing efficiency and performance under molding conditions in an amount of from about 35-70; and
   (e) an effective amount of a mold release agent for the release of the cured molding composition from a mold in an amount of from about 5-15 parts by weight.

2. The electrical connector of claim 1 wherein the socket front insulator 112 has a Shore A hardness in the range of 65-75, the pin front insulator 32 has a Shore A hardness in the range of 65-75 and the grommets 116,36 have a Shore A hardness in the range of 50-60.

3. The electrical connector of claim 1 wherein:
   the socket front insulator 112 is preferably fabricated from a mixture having an amount of about 110-130 parts by weight of the halogenated elastomer, an amount of about 30-40 parts by weight of the filler; and an amount of about 0.5-2.5 parts by weight of the mold release agent;
   the pin front insulator 32 is preferably fabricated from a mixture having an amount of about 85-115 parts by weight of halogenated elastomer, and amount of about 10-30 parts by weight of plasticizer, and an amount of about 3-9 parts by weight of mold release agent; and

the grommets 116,36 are preferably fabricated from a mixture having an amount of about 85-115 parts by weight of halogenated elastomer, an amount of about 30-40 parts by weight of filler, an amount of about 45-65 parts by weight of plasticizer and an amount of about 8-12 parts by weight of mold release agent.

4. The electrical connector of claim 1, 2 or 3 wherein the halogenated elastomer used for forming the socket front insulator 112, the pin front insulator 32 and the grommets 116,36 is comprised of a mixture of a halogenated polyolefin compound and an olefin compound.

5. The electrical connector of claim 1, 2 or 3 wherein the halogenated elastomer used for forming the socket front insulator 112 comprises a mixture of a fluorinated tetrafluoroethylenepropylene compound and an ethylene-propylene compound; and the halogenated elastomer used for forming the pin front insulator 32 and grommets 116,36 is a mixture of a chlorinated polyethylene compound and an ethylene-propylene compound.

6. The electrical connector of claim 5 wherein the ratio of the total weight of the tetrafluoroethylene/propylene compound to the weight of the ethylene-propylene compound is between about 5-25.

7. The electrical connector of claim 5 or 6 wherein the fluorinated tetrafluoroethylene/propylene compound comprises a mixture of high and low viscosity fluorinated tetrafluoroethylene/propylene compounds.

8. The electrical connector of any of claims 1 to 7 wherein mixture used to formulate the grommets 116,36 further includes a crosslinking agent sufficient to crosslink the composition under molding conditions in an amount from about 1-10 parts by weight.

9. The electrical connector of claim 8 wherein the plasticizer in the mixtures used to formulate the pin front insulator 32 and the grommets 116,36 is diisonono phthalate, and the crosslinking agent in the pinfront insulator 32 and grommets 116,36 is triallyl trimellitate.

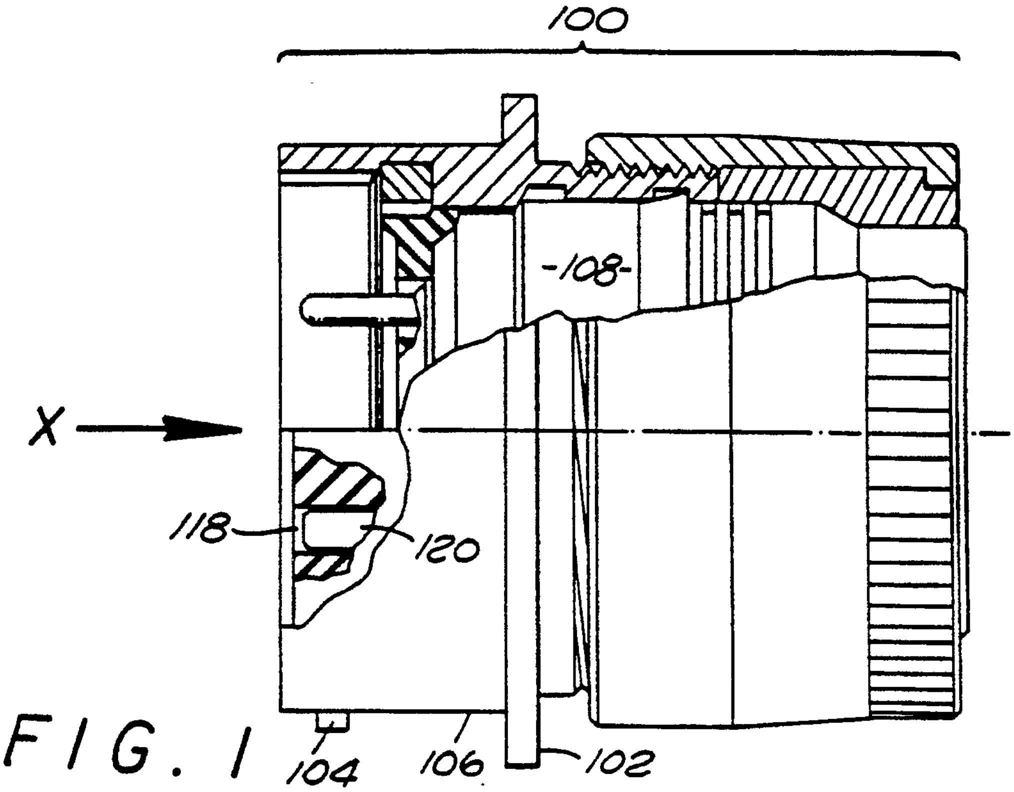

FIG. 1

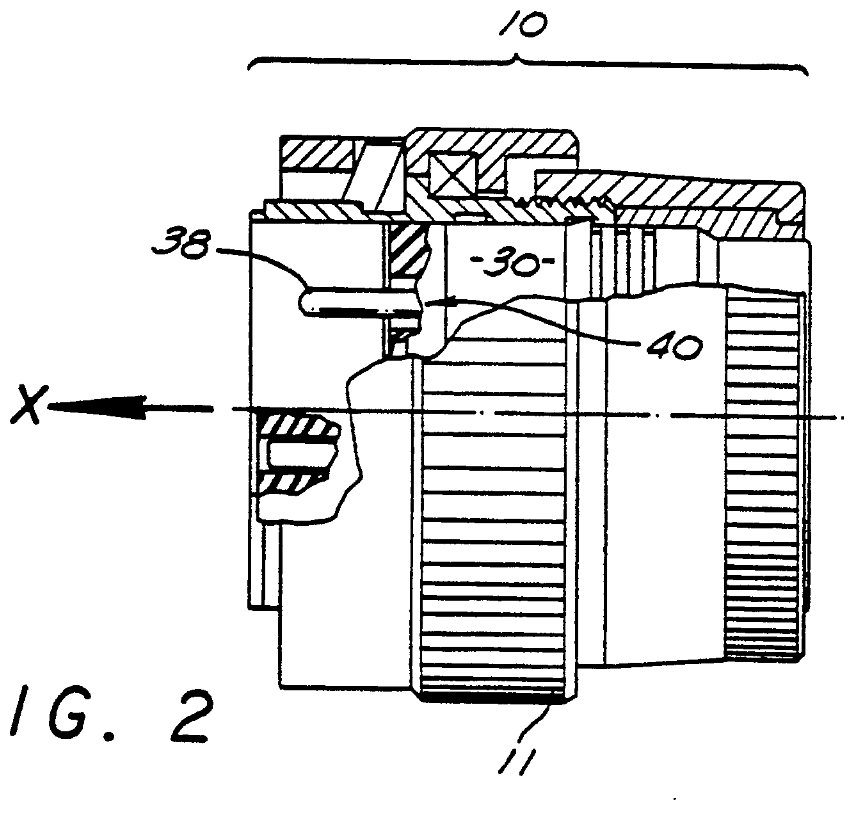

FIG. 2

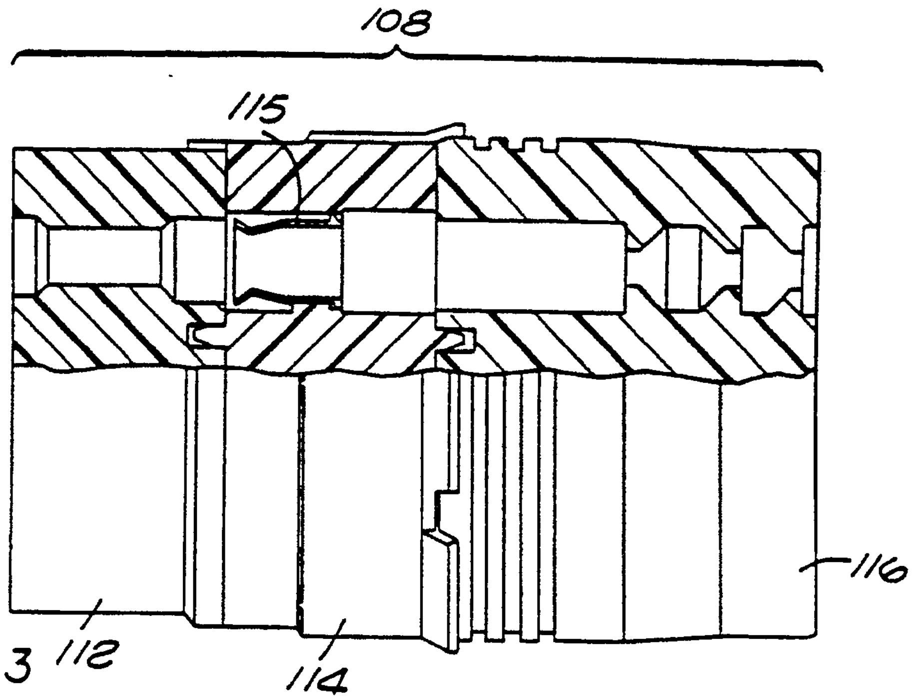

FIG. 3

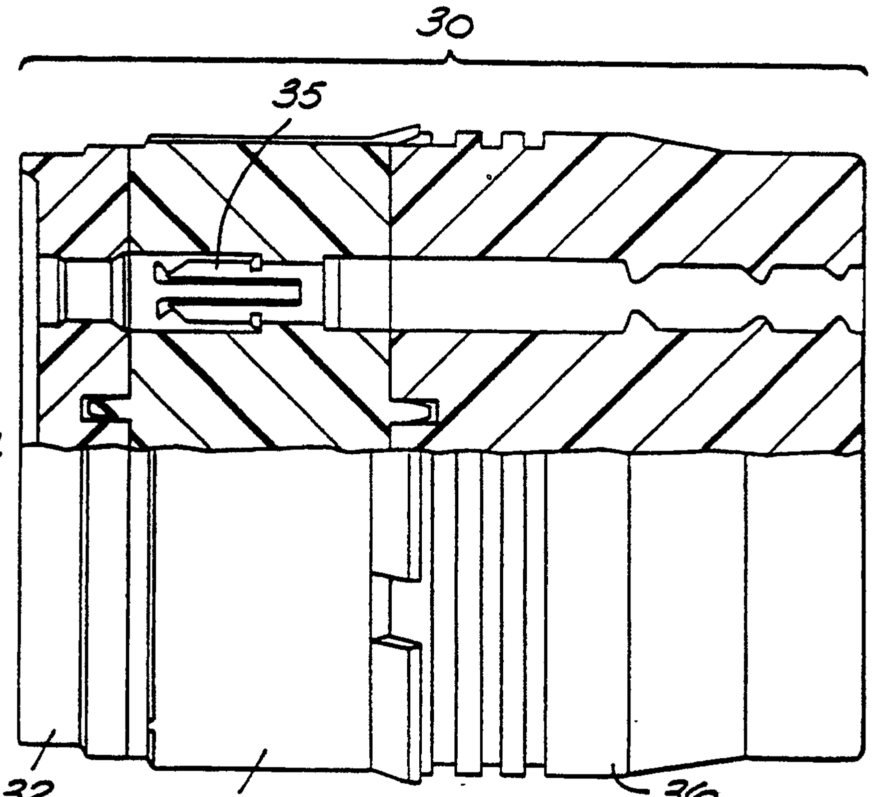

FIG. 4