July 1, 1969 G. W. ZIEGLER, JR., ET AL 3,453,376

CENTER CONTACT STRUCTURE FOR COAXIAL CABLE CONDUCTORS

Filed July 5, 1966 Sheet 1 of 2

Fig. 1

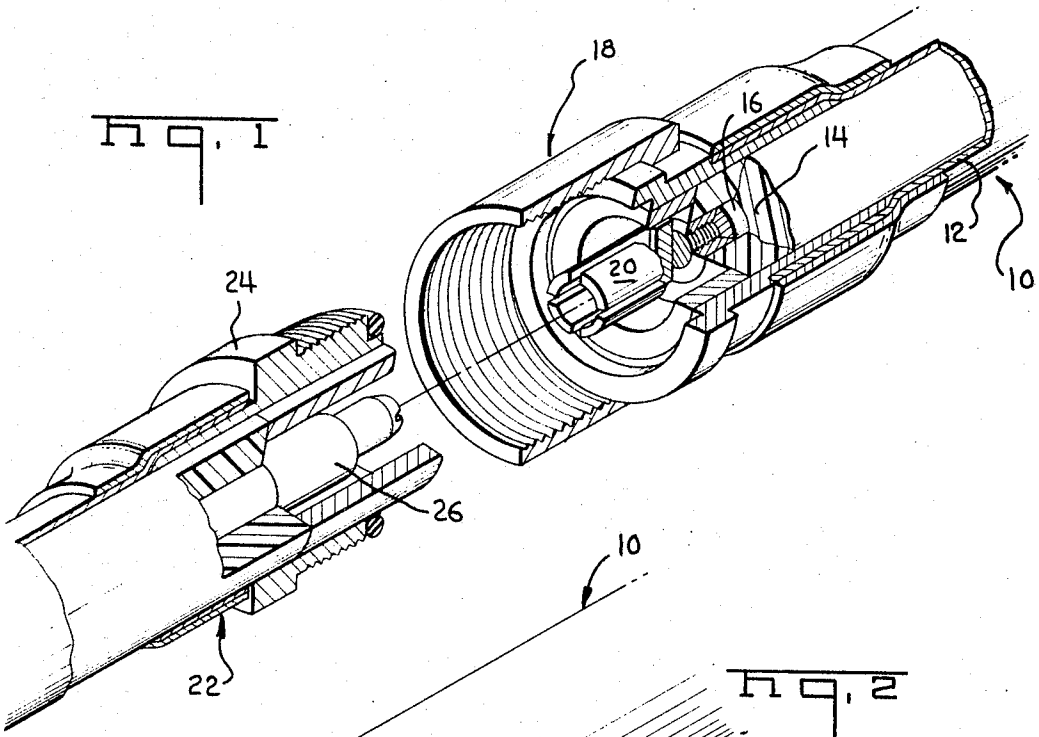


Fig. 2

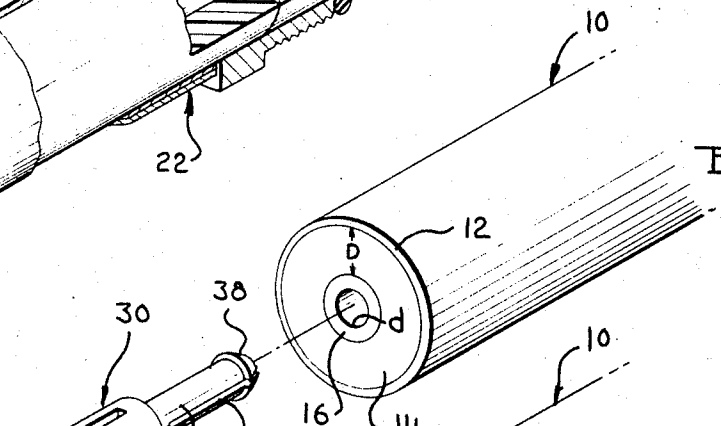


Fig. 3

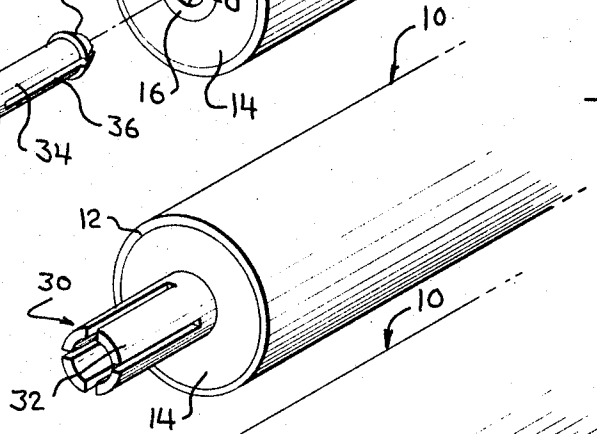


Fig. 4

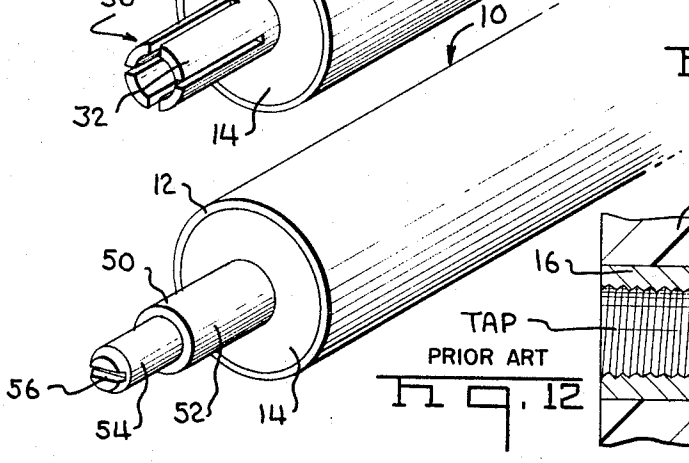
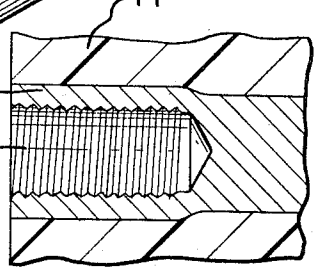


Fig. 12
PRIOR ART



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CENTER CONTACT STRUCTURE FOR COAXIAL CABLE CONDUCTORS

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Fig. 10

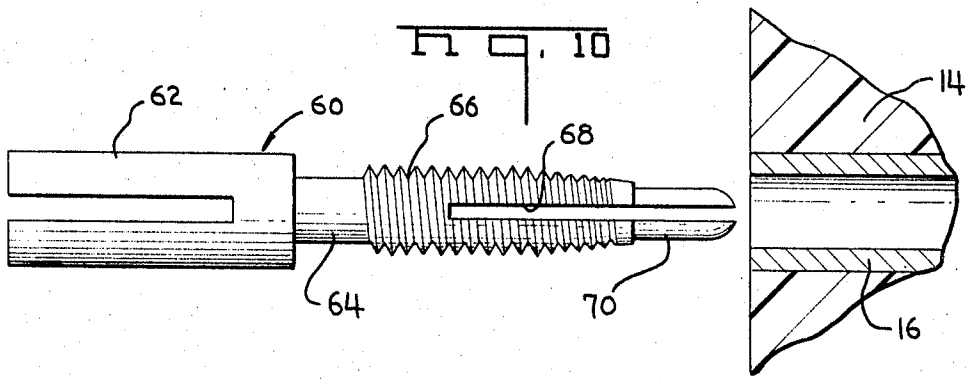


Fig. 11

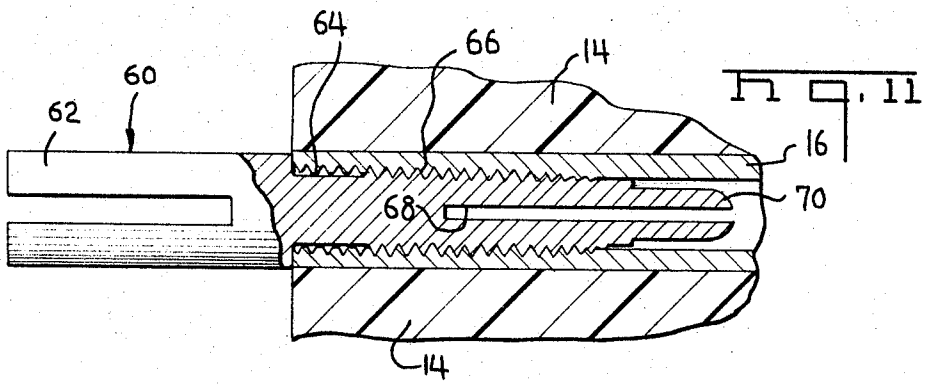


Fig. 5

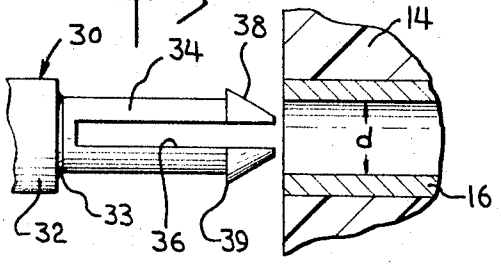
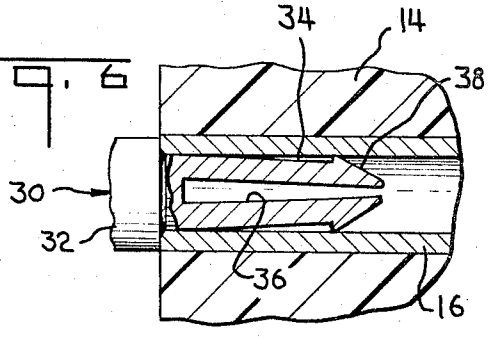


Fig. 6



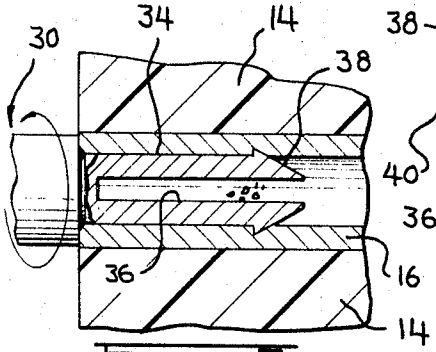


Fig. 7

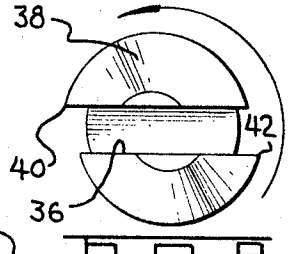


Fig. 9

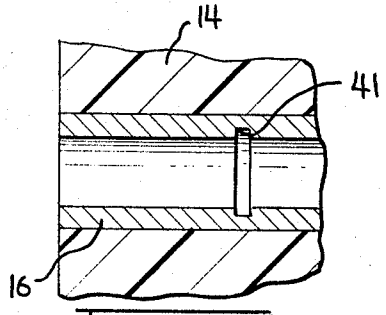


Fig. 8

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3,453,376

CENTER CONTACT STRUCTURE FOR COAXIAL CABLE CONDUCTORS

George William Ziegler, Jr., Carlisle, and Armand Samuel Apa, Camp Hill, Pa., assignors to AMP Incorporated, Harrisburg, Pa.

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U.S. Cl. 174—75
4 Claims

ABSTRACT OF THE DISCLOSURE

A center contact structure for coaxial cable connectors is disclosed which is insertable within the bore of a cable center conductor and includes spring arms carrying cutting edges adapted to bite into the inner wall of the cable center conductor and anchor the contact member thereto. The contact member is dimensioned relative to the cutting edges and the thickness of the cable center conductor wall so as to provide the anchoring action without bulging the exterior of the cable center conductor to adversely affect signal transfer.

Background of the invention

This invention relates to improvements in center contact structures for coaxial cable connectors.

In U.S. Patent No. 3,245,027 there is disclosed a type of coaxial connector which employs a center contact structure which fits into the center conductor of a coaxial cable. The coaxial cable there referred to is of a type which has a center conductor comprised of either a solid rod of conductive material or a tube of conductive material. In accordance with the invention there described in a use wherein the cable center conductor is solid rod the rod is prepared for use by drilling and tapping the center conductor and then fitting the center contact structure therein. In applications wherein the center conductor of the cable is hollow the conductor is merely tapped to provide threading to receive the center contact structure.

While the device of U.S. Patent No. 3,245,027 has been accepted as a substantial improvement in the art of connecting coaxial cable for high frequency applications, certain problems have arisen in practice due to differences in the many cables of different sizes being manufactured. One of these problems is that the center conductor of such cable is not fixed against rotation within the cable which makes it difficult, particularly in small sizes, to drill and tap the constructive material. Another problem arises if either the drill or tap is slightly off center to result in a distortion and bulging of the center conductor. A change in center conductor diameter as will be appreciated by reading U.S. Patent No. 3,245,027 is undesirable in that it changes the characteristic impedance along an appreciable length of the transmission line formed by the connector. This change in characteristic impedance produces reflections and increases the losses of the connector as well as causing a related degradation of signal transfer. A second problem with respect to those coaxial cables having a thin wall hollow center conductor is that the tapping procedure even when on center may cause bulging. The cable usually has a relatively thin wall section (sometimes on the order of 20 thousandths of an inch) and is made to a tolerance of approximately 4 to 5 thousandths of an inch. A slight variation in tolerance of the cable center conductor material will result in the tap forming the threads bulging the outer diameter of the center conductor to result in an appreciable discontinuity.

A further and practical problem related to the use of the device in 3,245,027 and to similar devices is one of performance and cost of application. If the user takes a great deal of time to accurately position the drill and tap and to carefully avoid bulging, the cost of installation is vastly increased. Even with such care there are occasions when there will be no tap available which can be used with an undersized cable center conductor. As those skilled in the art will appreciate it is generally unacceptable to make the performance of a high quality design device overly dependent upon the skill of the user. What happens all too frequently is that the user in his effort to reduce installation time and overall cost speeds up installation procedures with the result that a device of superior design gets put together in a manner which results in poor performance.

Summary of the invention

This invention relates to improvements in center contact structures for coaxial cable connectors. Accordingly, it is an object of this invention to provide a center contact structure for coaxial cable connectors which is arranged to facilitate an easy and reliable installation.

It is a further object of the invention to provide an improved center contact structure for coaxial cable connectors which eliminates the need for time consuming steps of cable preparation during installation of a connector onto a cable.

It is a still further object of the invention to provide a self-tapping center contact member for use with coaxial cable having a center conductor which is or has been hollowed out to receive a center contact structure inserted therein.

It is another object of the invention to provide a center contact member for coaxial cable connectors which has a design which better assures proper installation of contact structures and therefore improves the performance of coaxial devices used therewith.

The foregoing objectives are attained by providing a center contact member which is axially insertable into a hollow center conductor and includes cutting edges operating to bite into the material thereof to create a holding surface within the center conductor. The member includes a shank having spring characteristics to drive the cutting edges radially outward and a diameter to limit the penetration of the cutting edges to prevent bulging. The cutting edges of the member are supported by surfaces adjacent thereto which engage the holding surfaces caused by rotation of the cutting edges to resist axial pullout. The engagement effected thereby is in part against freshly exposed conductive material and is made to define a stable and low resistance interference.

In the drawings:

FIGURE 1 is a perspective of a coaxial connector attached to cable with portions shown in section to show the placement of the invention;

FIGURES 2–4 are perspectives showing the application of the invention center contact structure in one embodiment;

FIGURES 5–7 are sectional views showing installation procedure for the embodiment of FIGURE 2–A;

FIGURE 8 is a sectional view of an alternative installation procedure;

FIGURE 9 is an end view of an alternative embodiment of the center contact structure shown in FIGURE 4–7;

FIGURES 10 and 11 are sectional views of an alternative contact structure; and

FIGURE 12 is a sectional view showing the problem faced by the prior art.

Description of the preferred embodiment

In FIGURE 1 there is shown a coaxial connector arranged to electrically and mehcanically interconnect separate coaxial cables shown as **10**. The connector of FIG-

URE 1 is comprised of halves **18** and **24** which each include portions to provide mating of the halves in a manner to serve as a transmission path for signal energy carried over the cables **10**. U.S. Patent No. 3,245,027 is referred to for details as to the arrangement and detail features of the connector shown in FIGURE 1. It is contemplated that a wide variety of different coaxial connector designs may be served by the invention and the connector shown in FIGURE 1 is included to generally teach the environment of use of the invention.

For the purposes of disclosure the important points to consider relative to the connector are the characteristics of the cable **10** which is comprised of an outer conductive tubular member **12** surrounding a sheath of dielectric material **14** and a center conductor **16**. The center conductor **16** as shown in FIGURE 1 is formed of a solid copper rod which has been drilled and tapped as indicated in FIGURE 1 to receive the threaded end of a center contact structure. The structure is shown as **20** which is in the form of a female receptacle adapted to receive a male contact member shown as **26** in the half **24**. The male member **26** is connected to the center conductor of the cable to the left in the same manner as that shown with respect to half **18**.

Various types of cable are presently being employed and is contemplated that the invention may be used with such types with equal facility as with the exact type shown. For example, in certain types of cable the dielectric material shown as **14** is formed of space dielectric discs which support the center conductor **16**. Other types include a dielectric formed of a spirally disposed bead of dielectric material which extends helically along the cable to support the center conductor coaxially inside the outer conductor **12**. Still other types include a center conductor which is formed of a hollow copper tubing. Typically, this tubing has a thin wall section and it is such thinness of wall section which has caused a problem in prior devices.

Referring to this problem with respect to solid conductive material, FIGURE 12 shows how the center conductor has been prepared in accordance with prior techniques. First the center conductor is drilled to a depth as indicated in FIGURE 12 and then a tap is inserted to provide threading of the interior surface of the conductor. In the case of hollow center conductors the drilling step is not necessary and the tapping proceudre is performed directly on the center conductor. In either event the problem has been that the tap tends to cause a bulging of the conductive material as indicated in FIGURE 12 along the length of the hole which receives the center contact members **20** or **26**. This bulging is of a substantial length and it creates a change in diameter of the inner conductive path of the connector or cable along the length thereof which discontinuity causes signal reflections, degradation, low VSWR, and generally poor performance of the connector. As will be appreciated from a reading of 3,245,027 the particular connector design shown in FIGURE 1 is for high performance applications wherein it is important that the connector pass signal frequencies over a broad range extending up to 10 gHz. and beyond with a minimum VSWR.

The invention in one embodiment contemplates a center contact structure as indicated in FIGURE 2 by the numeral **30** and as indicated in FIGURE 4 by the numeral **50**. The forward ends of **30** and **50** are the mating center conductor halves for two connector halves and the rearward ends thereof are contemplated as being identical. In FIGURE 2 a cable is shown to have a hollowed out center conductor **16**. This may be assumed to be either a drilled solid conductor or as is frequently the case a hollow tubular member which does not require drilling. The member **30** and as previously mentioned the member **50** each include a portion which extends inside the bore in **16**. This portion relative to **30** includes a shank **34** slotted as at **36** along its length to provide a bifurcation and give the shank spring characteristics. Between the large end of **30** and shank **34** is a very slight chamfer **33**. The end of **34** is made to include a portion **38** which is beveled inwardly to facilitate insertion of **30** within the bore in **16** and includes a sharply radiused corner shown as **39** in FIGURE 2 at the point of maximum diameter of **38**. The remainder of the shank **34** is of a diameter reduced relative to the diameter at **39**. The diameter of **34** is controlled so that at its maximum (including tolerance) it will fit easily within the minimum (including tolerance) diameter of the bore of **16** shown as *d*. The shank **34** is made to be of a length to extend well down within **16** to establish a substantial spring force operating on **39** without being overly stiff.

Details of **30** and the installation thereof are better shown in FIGURES 5–7. In FIGURE 5, **30** is shown positioned prior to insertion within **16**. As can be seen the diameter of **39** is slightly larger than that of the diameter *d* within **16** but the bevel permits an easy insertion of **30**. In FIGURE 6 a member **30** is shown inserted within **16**. It will be noted that the corner at **39** loads the shank spring arms **34** biasing them inwardly. The member **30** is preferably made of a relatively hard conductive material and while the spring action defined by the bifurcation of **34** is substantial the member can be inserted by hand force. With the contact structure **30** positioned as shown at FIGURE 6 it is then rotated as indicated in FIGURE 7. It has been found that one or two turns are sufficient to cause the sharp leading edges (at the intersection of slot **36** and corner **39**) to dig into the conductive material of **16** until the diameter of **34** is reached and the surface of **34** is in substantial contact with the inner surface of **16** at least at the end near **39**. It has been found that the torsional loading applied after insertion causes the edges to operate to bite into the material of **16** with the remainder of the surface area of the corner of **39** following the edges down into the groove created in **16**. Control of the diameter of **34** absolutely precludes bulging of the outer surface of the center conductor. As **30** is rotated in the manner shown in FIGURE 7 any chips or particles cut from the material of **16** are accommodated by the slot shown as **36**. The chamfer **33** serves to center the member **30** in **16** in firm engagement therewith to prevent looseness in use with the larger tolerance conductors without causing a bulge.

In an actual unit members like **30** and **50** were dimensioned (in inches) as follows. Each member had a maximum diameter of about approximately 0.248 for use with a cable having a center conductor having a diameter of approximately 0.248. The center conductor had an inner bore of a little more than 0.202 and the diameter of the shank **34** was made to be about 0.202. The diameter at **39** was made to be about 0.212 to thus limit the penetration thereof into the wall material of the outer conductor to about 0.005. The overall length of the shank was made to be about 0.750 with the portion **38** being made of a length approximately 0.120. The edges at **39** were left as machined and were not de-burred. In use the unit was inserted within a cable and given two full turns. The pull-out force resulting exceeded 15 pounds. In the typical application, as in the connector previously described, the center contact structure is not utilized to mechanically hold the cables together and 5 to 12 ounces of pull-out force is generally sufficient. The unit was comprised of beryllium copper machined to the configuration shown and silver plated. An electrical continuity check showed that a low resistance resulted.

In FIGURE 8 an alternative embodiment of the invention is shown wherein the center conductor is reamed at one place shown as **41** prior to insertion of the member **30**. This may be accomplished by a number of procedures including the use of a bit shaped like **30** which is compressible for withdrawal. The extra axial space provided at **41** operates to assure an easy fit of the member **30**. The member **30** is then snapped into place. This

approach may be preferred if the center conductive material is particularly hard relative to the conductive material of the member **30**. For example, if the member **30** must for other reasons be of brass and the center conductor is of a hardened material such as stainless steel the method and technique indicated by FIGURE 8 may be preferred.

FIGURE 9 shows an alternative embodiment wherein the bifurcation formed in the shank **34** is given a slight axial offset exposing the corners **40** and **42** in the manner indicated but somewhat exaggerated in FIGURE 9. These corners then are better placed in a position to cut the material within the center conductive member. In an actual unit the offset was made to be between 0.003 and 0.005 of an inch. This increased the pull-out force to 65 pounds.

FIGURE 10 shows an alternative embodiment of the invention wherein a center contact structure **60** carrying a contact portion such as **62** is made to have a shank **64** carrying on the outside a series of threads **66**. These threads are made to taper down to a smooth portion toward the forward end of the member which carries a portion such as **70** to facilitate insertion within the conductor. There is a slot provided as at **68** which permits the member to have spring characteristics in the forward end to ease insertion and to facilitate the self-tapping technique which results from use of the unit. The slot also accommodates any particles cut from the inside of the center conductor **16**. The depth of the threads **66** is held and limited carefully to avoid the bulging effect heretofore discussed. For example, in an actual unit for use with a center conductor having an outer diameter of approximately 0.248 of an inch and a bore of approximately 0.208 of an inch the threads are made to have a maximum depth of 0.008 of an inch; less than half the wall thickness of the center conductor. This was found not to bulge the center of the conductor of a cable in application and to provide a very substantial pull-out force relative to that actually required.

This latter embodiment was also found to provide even better electrical characteristics and may be preferred in applications wherein the center conductor is of hollow tubing which could conceivably have some greater amount of oxidation products on its inner surface than would be the case if solid tubing were freshly drilled. The latter embodiment is useful in applications wherein it is desirable to non-destructively remove the center contact structure.

With respect to the embodiments of FIGURES 2–7 removal may be provided by giving the face of **39** opposite to the bevel a slight chamfer which serves to cam the spring arms in upon axial withdrawal. Control of the angle of this chamfer can be readily made to provide a pull-out force exceeding 5 pounds but non-destructive to the conductor **16** and the center contact member.

With respect to all of the various embodiments it is contemplated that the shank may be split to provide more than the two arms shown. For example, the shank **34** could be made to have two slots **36** intersecting to provide four arms. The end structures **38** and **39** would be identical with additional biting edges provided at each slot.

In reference to the cutting or biting edges heretofore described it is important that sharpness be maintained in manufacture. In both embodiments the corner radius should be preferably no more than 0.003. In the embodiment wherein there is a spiral thread the flat or top of the thread should particularly be held to a minimum because it is the flat that causes bulging by radially pushing them aterial of the center conductor outwardly. It is also important to provide a sufficient pitch in the threaded version to hold the force required to rotate the contact member into the center conductor to prevent swisting of the center conductor in those cables having a non-solid dielectric. For example, on a center conductor having a bore of approximately 0.208 of an inch the pitch might be on the order of 32 to 44 threads per inch.

Having now disclosed and described my invention in terms intended to enable its preferred practice, I define it through the appended claims.

What is claimed is:

1. As an article of manufacture for use with coaxial cable an improved contact structure including a forward portion having a contact surface thereon for mating connection with a further conductive member and a rearward portion for connecting said structure to the center conductor of a coaxial cable having a bore therein, said rearward portion having a diameter to be inserted into said bore and including means responsive to insertion and to rotation of said structure within said bore to cut into the material of said conductor and anchor said structure to said conductor against axial pullout and electrically connect said structure to said conductor, the said means including at least one axially extending spring arm having at least one cutting edge biased outwardly by said arm along a radius of the rearward portion, said arm extending slightly off center with respect to said rearward portion in a direction normal to said radius, to place said cutting edge outwardly of the body of said rearward portion to better facilitate the cutting operation of the edge.

2. In a coaxial cable having a center conductor of a uniform diameter throughout its length including a center bore and a contact member therein, said contact member being of conductive material including a first portion for connection to a conductive member and a second portion fit within the cable center conductor bore, the second portion including a spring arm carrying on the outer surface thereof at least one raised cutting edge biased by said arm outwardly of the axis of the contact member, means on the said contact member to guide said second portion of said contact member into said bore, the said raised cutting edge cutting into the inside wall of said bore and means on said contact member limiting the depth of penetration of said edge to avoid bulging of said conductor, the said edge being biased by said arm into engagement with the inside wall of the bore holding said contact member in electrical and mechanical engagement with said center conductor.

3. The article of manufacture of claim **2** wherein said second portion is tapered along the length thereof facilitating insertion within said conductor with a minimum force of rotation required.

4. Thearticle of claim **2** wherein said cutting edge is formed in a single plane transverse to the length axis of said second portion.

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DARRELL L. CLAY, *Primary Examiner.*

U.S. Cl. X.R.

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