United States Patent

[11] 3,601,526

[72] Inventors **Frederick G. Bohne**
Buffalo;
Mark O. Johnson, Grand Island, both of, N.Y.

[21] Appl. No. **748,715**
[22] Filed **July 30, 1968**
[45] Patented **Aug. 24, 1971**
[73] Assignee **Conax Corporation**
Buffalo, N.Y.

[54] **ELECTRICAL PENETRANT STRUCTURE**
3 Claims, 12 Drawing Figs.

[52] **U.S. Cl.** ..... **174/151,** 29/517, 29/624, 29/629, 174/11 R, 174/23 R, 174/65 SS, 174/77 R
[51] **Int. Cl.** **H01b 17/26**
[50] **Field of Search** ..... 174/11 R, 18, 23 R, 77 R, 65 R, 65 SS, 151

[56] **References Cited**

UNITED STATES PATENTS

452,342	5/1891	Conner	174/23
3,055,972	9/1962	Peterson	174/65 (.1) X
3,104,277	9/1963	Bossu	174/151
3,109,055	10/1963	Ziegler	174/77 X

Primary Examiner—Laramie E. Askin
Attorney—Sommer, Weber & Gastel

ABSTRACT: An electrical penetrant structure, and a method of making the same, are disclosed for feeding sealingly one or more electrical conductors through a wall, such as the containment vessel wall in a nuclear-powered electrical generating station. The penetrant structure comprises a tubular metal housing through which a metal conductor extends noncentrally but in spaced relation to the surrounding housing wall surface, such surface being annularly recessed ro provide an enlarged chamber filled with resilient insulating material in compression and surrounding a laterally offset portion of said conductor. The method for making such structure involves swagging an assembly of the housing having an external groove therein surrounding a body of insulating material having a noncentral hole through which the conductor extends, this swagging causing the insulating material to be compressed between the housing and conductor and the portion of the conductor adjacent the groove to become laterally offset while embedded in the insulating material.

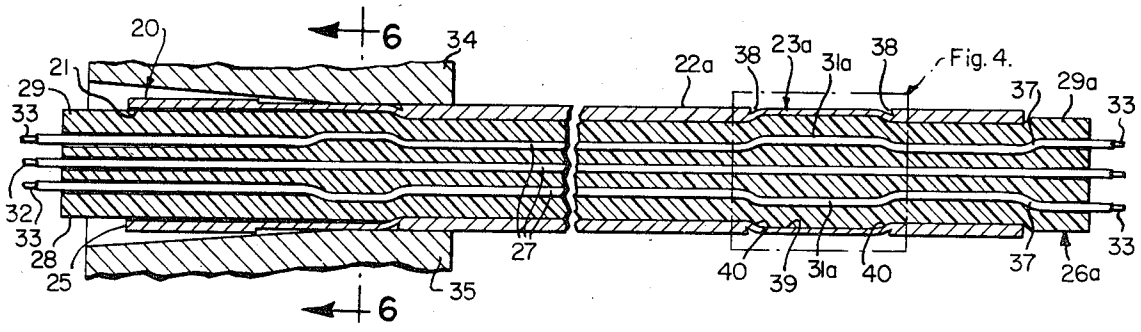
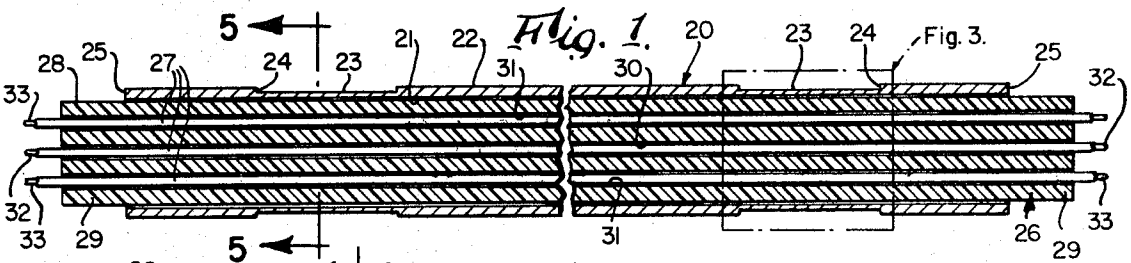


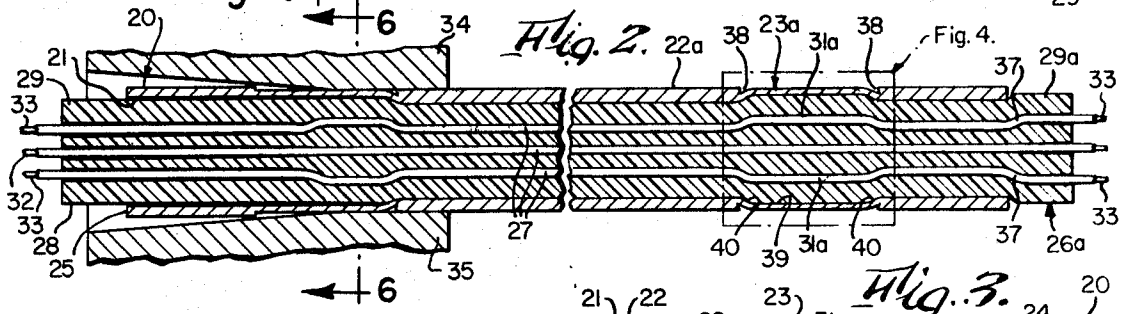
Fig. 4.

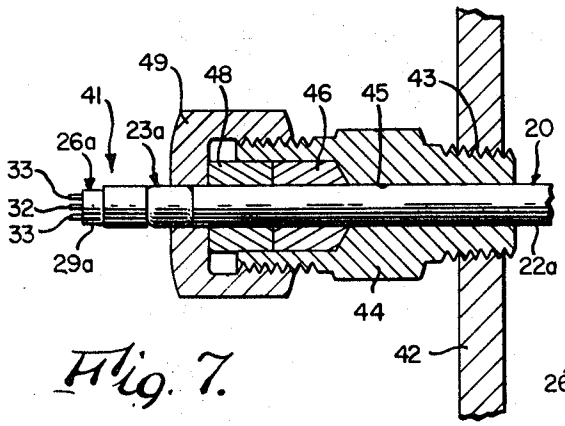
PATENTED AUG 24 1971

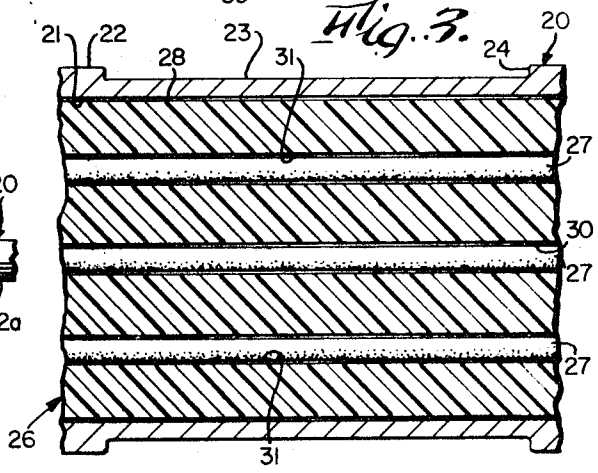
3,601,526

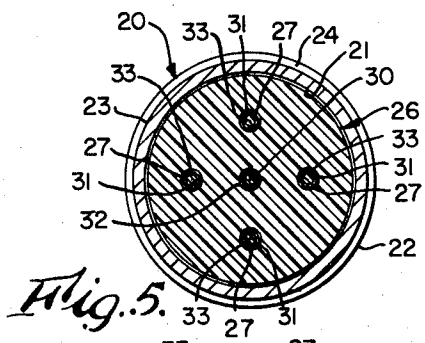
SHEET 1 OF 3

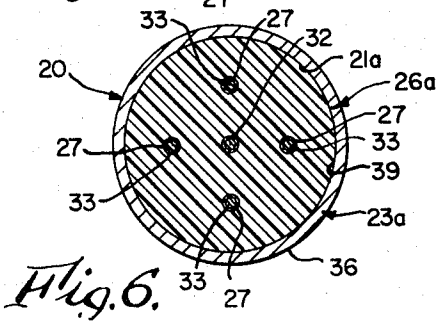


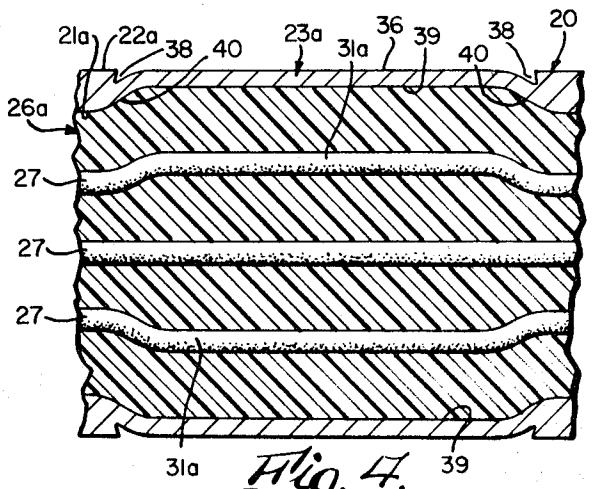












INVENTORS
Frederick G. Bohne
Mark O. Johnson
BY
Sommer & Weber
ATTORNEYS

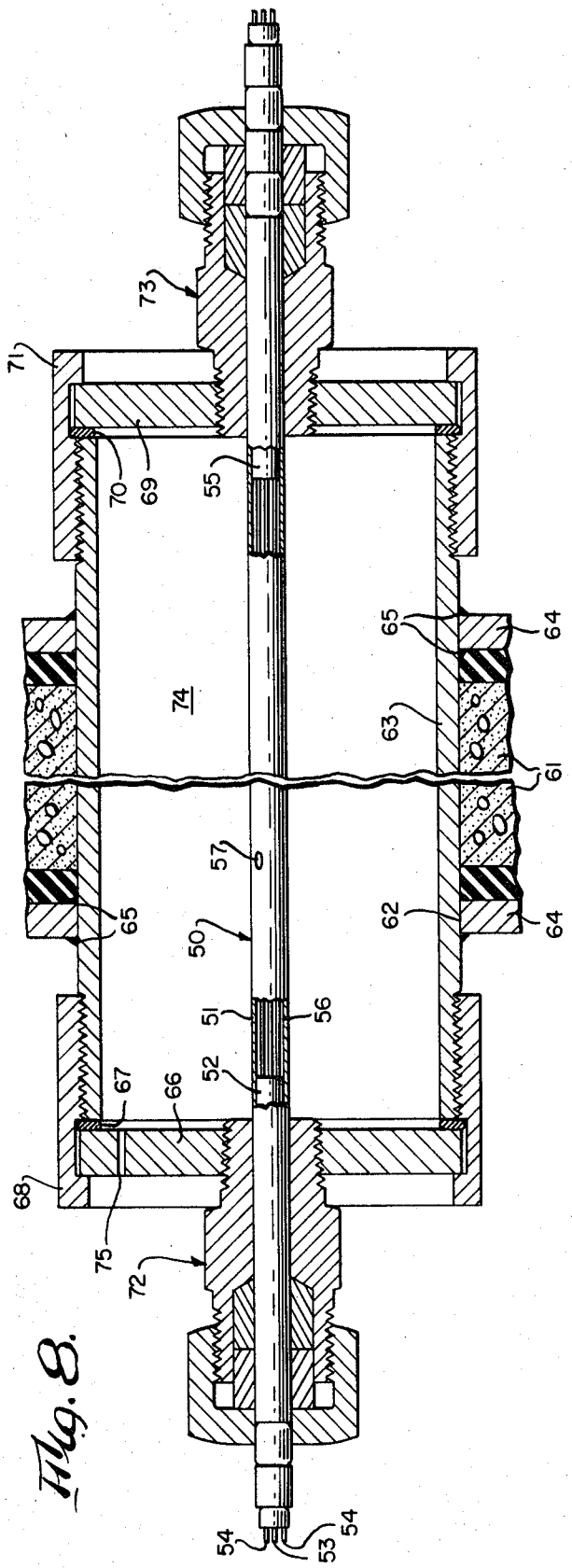


Fig. 8.

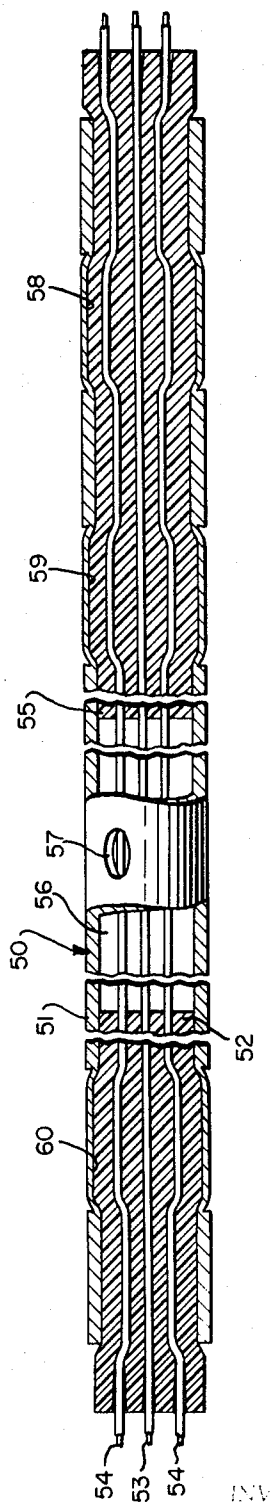


Fig. 9.

INVENTORS
Frederick G. Bohne
Mark O. Johnson
BY
Sommer & Weber
ATTORNEYS

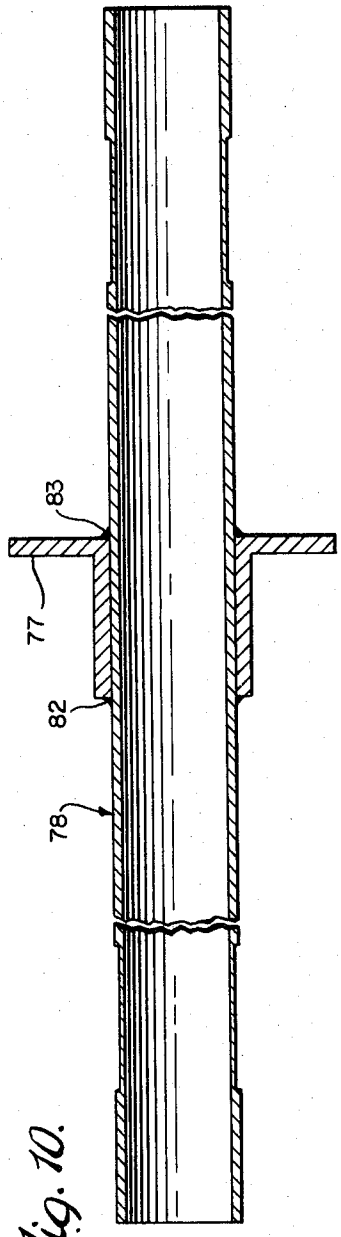


Fig. 10.

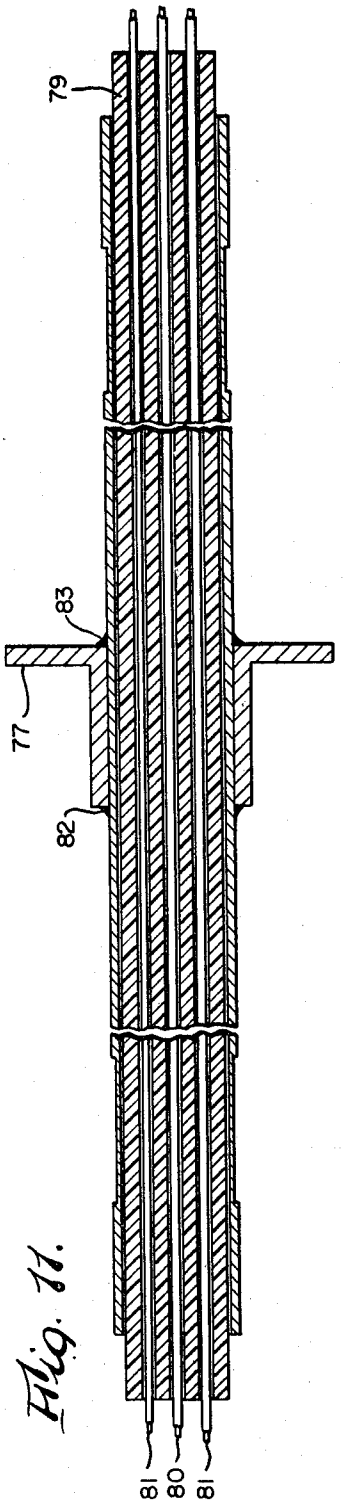


Fig. 11.

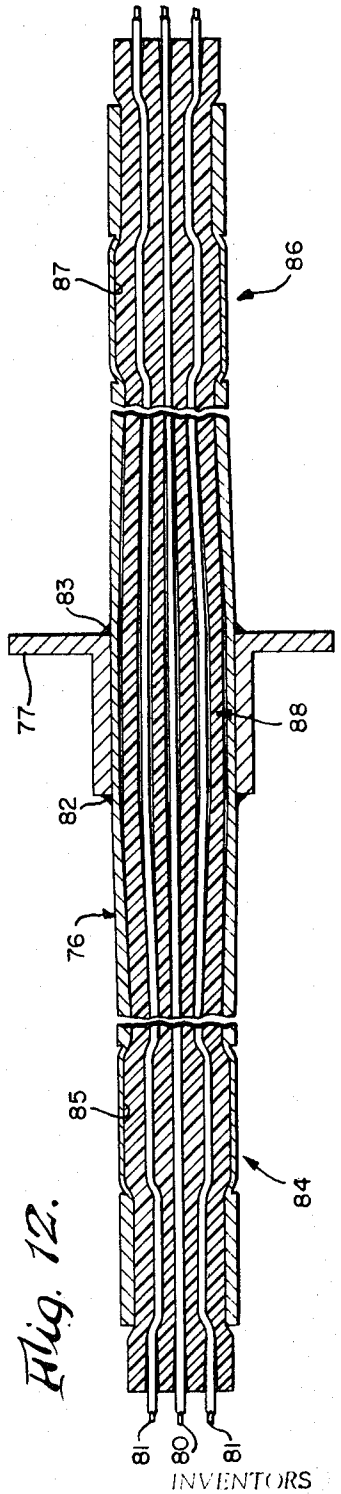


Fig. 12.

INVENTORS
Frederick G. Bohne
Mark O. Johnson
BY
Sommer & Weber
ATTORNEYS

ELECTRICAL PENETRANT STRUCTURE

BACKGROUND OF THE INVENTION

There are environments in which it is desirable to feed an electrical conductor through a wall so that the conductor is not only insulated from the wall but also penetrates the wall in a sealed manner so that fluids on one side of the wall cannot escape through the electrical penetrant structure. This presents problems in effectively sealing the conductor, as well as mounting the same on the wall which it penetrates. The present invention is addressed to a solution of these problems.

SUMMARY OF THE INVENTION

The electrical penetrant structure of the present invention comprises an elongated metal tubular member which penetrates the wall and houses a body of compressed resilient insulating material with one or more electrical conductors extending through such body. Swaging is employed to unitize a loose assembly of housing, insulating bodies and conductor elements to provide the final electrical penetrant structure. The housing is externally grooved before swaging so as to provide after swaging an internal contoured sealing chamber into which the insulating material is forced, and to cause any noncentral conductor to be laterally offset at such chamber, thereby to lock the various elements together mechanically while forcing them into sealing engagement with one another.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a fragmentary longitudinal sectional view through a loose assembly of housing, insulating body and conductor elements prior to swaging in accordance with the present invention.

FIG. 2 is a view similar generally to FIG. 1 but depicts the condition of the assembly after being substantially fully swaged from end to end, thereby to illustrate the final construction of the electrical penetrant structure which represents one form of the present invention.

FIG. 3 is an enlarged fragmentary portion of the section shown in FIG. 1 taken near the right end thereof.

FIG. 4 is an enlarged fragmentary portion of the section shown in FIG. 2 taken near the right end thereof.

FIG. 5 is an enlarged transverse sectional view of the assembly shown in FIG. 1 and before swaging taken on line 5—5 thereof.

FIG. 6 is an enlarged transverse sectional view of the final electrical penetrant structure after swaging, this view being taken on line 6—6 of FIG. 2.

FIG. 7 is a longitudinal sectional view through one means for mounting on a wall the form of inventive electrical penetrant structure shown in FIGS. 1–6.

FIG. 8 illustrates another technique of mounting on spaced walls a modified form of electrical penetrant structure made in accordance with the present invention.

FIG. 9 is an enlarged fragmentary longitudinal view, principally in central section, of the modified form of electrical penetrant structure shown in FIG. 8.

FIG. 10 depicts an elongated metal tubular housing member which will ultimately form an element of still another form of inventive electrical penetrant structure and showing such member welded to a mounting bracket prior to association with the other elements of the penetrant structure.

FIG. 11 shows the housing member just referred to loosely assembled with an insulating body and conductor elements, prior to swaging.

FIG. 12 depicts the assembly after swaging and illustrates the final construction of this form of electrical penetrant structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

There are three preferred embodiments of electrical penetrant structure illustrated in the accompanying drawings.

Each will be described under separate subheadings of the Figures of the drawings which illustrate the corresponding form of electrical penetrant structure. Accordingly, the first preferred form of the invention will be described in connection with FIGS. 1–7; the second form in connection with FIGS. 8 and 9; and the third form in connection with FIGS. 10–12.

FIGS. 1–7

The numeral 20 represents generally an elongated tubular metal housing. It is preferably cylindrical in cross section throughout its length. As shown in FIG. 1, this housing has a cylindrical bore 21 of uniform diameter from end to end. The housing also has an external periphery 22 concentric to bore 21 and which is uniform from end to end except for an interruption adjacent each end which will now be described.

Adjacent each end, housing 20 is shown as provided with an external annular groove 23 for purposes which will be explained later. Each groove 23 must have a radial depth at least equal to one quarter of the wall thickness of housing 20. Also, each groove 23 must have an axial length before swaging as hereinafter explained which is at least equal to the radius of the external diameter of the ungrooved portion of the housing 20 before swaging. Still further, the outer radial end wall 24 of each groove 23 must be arranged axially inwardly from the adjacent outer end face 25 of housing 20 a distance at least equal to the outside diameter of peripheral surface 22 of the housing 20 prior to swaging. This housing 20 may be made of any suitable metal or metal alloy such as stainless steel.

Referring to FIG. 1, arranged symmetrically within tubular housing 20 is an elongated cylindrical body of resilient insulating material represented generally by the numeral 26. The external periphery 28 of insulating body 26 is cylindrical and spaced slightly from the opposing internal cylindrical surface 21 of surrounding housing 20. Typically the clearance between opposing surfaces 21 and 28 is 0.0025 to 0.003 inch. Body 26 is shown as having an axial length greater than that of housing 20 so that a portion of the body extends outwardly beyond end face 25 at each end of the housing, each such extension being indicated at 29. The insulating body 26 may be an suitable thermoplastic such as tetrafluoroethylene, elastomer such as rubber or neoprene, or epoxy resin.

As shown in FIG. 5, insulating body 26 has a series of five symmetrically arranged through holes severally adapted to receive conductors. One such hole is centrally arranged and extends coaxially of cylindrical body 26 and is designated 30. At equidistant circumferential intervals and at a uniform spacing radially between the axial centerline of cylindrical body 26 and its cylindrical periphery 28 are the four remaining through holes typically represented by the numeral 31. All the holes 30 and 31 extend generally parallel to one another.

As stated, a conductor is arranged in each such hole 30 and 31. The central conductor is represented by the numeral 32 and typically the conductor in each of the other holes 31 is represented by the numeral 33. The central conductor 32 and the noncentral conductors 33 are each made of a suitable solid metal or combination of metals so as to provide an incompressible wire capable of withstanding the radial pressures exerted during the swaging operation as explained later herein. These conductors may be made of any metal, or combinations of metal, such as copper, nickel or a thermocouple element such as iron-constantan or chromel-alumel.

The conductors 32 and 33 are preferably in the form of cylindrical wires and may be coated or uncoated with a sleeve of insulating material. As shown, each of the conductors 32 and 33 is preferably encased in a sleeve 27 of suitable insulating material. The conductors 32 and 33 are of a length greater than that of the body of insulating material 26. The ends of these conductors are adapted to be connected to other leads or conductors in any suitable manner, no such connection being illustrated since it forms no part of the present invention.

The conductors 32 and 33 are placed within their respective holes 30 and 31 in the body 26 of insulating material. To permit of this, a slight clearance between the opposing surfaces is

provided, this clearance also being in the order of 0.0025 to 0.003 inch.

From the foregoing, it will be seen that the housing **20**, insulating body **26** and conductor elements **32** and **33** can be readily assembled to provide the loose assembly depicted in FIG. **1**. Thereafter this loose assembly is swaged in a conventional swaging machine having swaging dies typically illustrated at **34** and **35** in FIG. **2**. As is well known, the item to be swaged, here specifically the loose assembly of housing **20**, insulating body **26** and conductors **32** and **33**, is fed axially through the opening formed by the swaging dies **34** and **35**. Suitable drive means (not shown) cause these dies to move toward each other and in the process the loose assembly is radially compressed to a smaller diameter than it had as depicted in FIG. **1**. Referring to FIG. **2**, the slightly more than right half of the electrical penetrant structure depicted therein has been swaged whereas the left-hand portion of the assembly shown surrounded by the swaging dies **34** and **35** has not as yet been swaged.

Referring to FIGS. **2** and **4**, it will be seen that as a result of the swaging operation the wall section of metal housing **20** formed under annular groove **23** is offset outwardly with respect to the adjacent wall portions of this housing. As shown in FIG. **4**, this offset wall section **23***a* has an external surface **36** which is coterminous with the adjacent external periphery **22***a* of the tubular housing at opposite ends of wall section **23***a*. The external surface, in other words, has substantially the same diameter over the portions of the housing which had been provided with grooves **23** as compared with the portions of the housing unprovided with such grooves. After swaging, the exterior of housing **20** where groove **23** had been is detectable only by the annular slanted V-shaped grooves typically indicated at **38**, one at each end of where the end wall of groove **23** had been.

Offset wall section **23***a* has an internal surface **39** which is offset radially outwardly with respect to the final internal wall surface **21***a* of housing **20**. In other words, the diameter of internal annular wall surface **39** is greater than that of annular internal wall surface **21***a*. The transition from the diameter of wall surface **21***a* to that of wall surface **39** is gradual as indicated at **40** at each end of wall section **23***a*. The portion of the interior of housing **20** after swaging defined by transitional end portions **40** and intermediate enlarged wall surface **39** provide a contoured chamber or enlarged chamber into which as a result of the swaging operation a portion of body **26** extends to transversely fill and seal this chamber.

It is pointed out that as a result of the swaging operation all of the clearances that had existed between the housing **20** and insulating body **26** and also between the latter and the various conductors **32** and **33**, have been eliminated. In fact, the original insulating body **26** has been compressed radially between the end limits **25** of housing **20** into a new body designated **26***a* which is in a state of compression and firmly and sealingly engages the internal surface of the housing and the various conductors **32** and **33** which this body surrounds. More specifically, the central conductor **32** is sealingly grasped by body **26***a*. In the case of the satellite conductors **31**, each has a laterally offset portion **31***a* which is offset radially outwardly toward wall surface **39** of the housing. The effect of this offset is to mechanically interlock conductors **32** to insulating body **26***a*. As previously noted, the transverse filling of the enlarged internal chamber formed by surfaces **39** and **40** serves to interlock insulating body **26***a* to housing **20**. Not only does there exist this mechanical interlocking, but as well the insulating body **26***a* is firmly compacted against the internal surfaces **21***a*, **40** and **39** of metal housing **20** and also against the external surfaces of conductors **32** and **33**.

The amount of reduction in gross diameter of the electrical penetrant structure after swaging as compared to before swaging coupled with the initial clearances referred to between the opposing surfaces of the three types of elements, namely conductors, insulating body and metal housing, are such as to produce at least a 10 percent reduction in the cross-sectional area of the insulating body. In other words, at a cross section where a groove **23** has been, the cross-sectional area of insulating body **26** before swaging has been reduced at least 10 percent after swaging to form body **26***a*.

Referring to FIGS. **1** and **2**, it will be noted that an internal contoured sealing chamber is provided adjacent each end of the electrical penetrant structure to prevent leaks axially through this structure either along the interface between the insulating body and the surrounding metal housing or along the interface between the various conductors which extend through the insulating body.

Referring to FIG. **2**, it will be noted that after swaging the portion **29***a* which extends axially outwardly of the adjacent end of the metal housing has an uncompressed condition as compared to that portion of the body confined within the metal housing **20** and reduced in cross-sectional area as a result of the swaging operation. This provides a slight offsetting as indicated at **37** of the satellite conductors **33** and also provides a gradually enlarging clearance for the end portions of the wires as they leave the insulating body and protects these wires against sharp bending adjacent metal housing **20**.

Referring to FIG. **7**, a suggested type of mounting is disclosed for the swaged electrical penetrant structure just described which in that FIG. is represented generally by the numeral **41**. As indicated hereinabove, the purpose of the electrical penetrant structure is to feed the conductors in a sealed and insulated manner through a wall. In FIG. **7** such wall is indicated at **42**. It is shown as having an internally threaded hole **43** which receives the externally threaded nipple of a gland body **44**. This gland body is shown as having an internal through bore **45** through which electrical penetrant structure **41** extends. The outer end portion of this bore **45** is shown enlarged to accommodate a sealing body **46** backed up by a gland follower **48**. A cap **49** threadedly connected to gland body **44** enables pressure to be applied to gland follower **48** and compress sealant **46** so as to sealingly engage and firmly grip the external surface of electrical penetrant structure **41**. The arrangement shown in FIG. **7** is merely suggestive. Any other suitable means or mode of mounting the electrical penetrant structure **41** may be employed.

FIGS. **8–9**

FIG. **9** illustrates a construction of electrical penetrant structure embodying a modified form of the invention. Referring to this FIG., the inventive structure represented generally by the numeral **50** includes a metal housing **51**, a body of resilient insulating material **52** arranged at the left end of this housing, a central conductor **53** and a plurality of uniformly spaced satellite conductors **54** extending though this insulating body. The body **52** of insulating material does not extend completely through the metal housing **51**. A separate body **55** of insulating material is arranged internally of housing **51** adjacent the right end portion of this housing. The opposing end faces of insulating bodies **52** and **55** are axially spaced from each other to provide an internal space **56** within housing **51**. Communication to the outside of this housing from this space is provided by a hole **57** in housing **51**, provided therein prior to swaging. The purpose of this hole is to allow the introduction of pressurized gas into space **56** to test for leakage of the electrical penetrant structure **50**.

It will also be noted that the right end portion of electrical penetrant structure **50** as shown in FIG. **9** is provided with two contoured sealing chambers, an outer one indicated at **58** and an inner one indicated at **59**. The left end portion of the electrical penetrant structure **50** has only one contoured sealing chamber indicated at **60**. Except for the differences noted, the construction and manufacture method of the modified form of electrical penetrant structure **50** shown in FIG. **9** is similar to that shown in FIGS. **1–7**.

FIG. **8** illustrates a manner of mounting electrical penetrant structure **50** on a wall **61**. This wall is shown as having a cylindrical opening **62** in which a cylindrical metal pipe **63** is arranged and this pipe is shown as sealed to the outer metal

plates 64 of wall 61 by having a welded connection indicated at 65 which extends annularly of hole 62. An end wall in the form of a plate 66 of circular outline is arranged opposite the left end of pipe 63, an O-ring 67 being interposed therebetween for sealing purposes. An end cap 68 clamps end wall 66 against pipe 63. At the opposite end of the structure a second end wall 69 is arranged against the right end face of pipe 63 with an O-ring 70 being interposed therebetween. A cap 71 clamps end wall 69 against pipe 63.

End wall 66 is shown as having a packing gland fitting represented generally by the numeral 72 which is similar in detailed construction to that described in connection with FIG. 7. This fitting sealingly mounts the left end portion of electrical penetrant structure 50 on left end wall 66, the fitting having a threaded connection with this end wall. At the right end of electrical penetrant structure 50, another packing gland fitting 73 similar to the one indicated at 72 mounts the right end portion of electrical penetrant structure 50 on end wall 69, this fitting 73 having a threaded mounting on this end wall. It will be noted that the hole 57 in electrical penetrant structure 50 communicates with the chamber 74 defined by pipe 63 and end walls 66 and 69. A pressurized test gas can be admitted to this chamber 74 to be forced into space 56 in the electrical penetrant structure 50 and detection is then attempted of this gas if it escapes axially outwardly along structure 50. For the purpose of admitting the text gas into space 74, left end wall 66 is shown as provided with an access hole 75.

FIGS. 10–12

The electrical penetrant structure represented generally by the numeral 76 is a third form of the invention and is depicted in its final form in FIG. 12. This structure 76 is characterized by having an attaching bracket 77 welded to the metal housing 78 to permit of mounting the electrical penetrant structure on some suitable support (not shown). Inasmuch as the welding operation could distort the electrical penetrant structure if performed after this structure was in its final form following swaging, it is desirable to attach the mounting bracket 77 shown in FIG. 10 to metal housing 78 prior to even a loose assembly of this housing with a body 79 of insulating material and a central conductor 80 and a series of satellite conductors 81, all as shown in FIG. 11.

Returning to FIG. 10, it will be noted that housing 78 is similar to housing 20 shown in FIG. 1 except that prior to the assembly of the insulating body and the conductors therewithin the mounting bracket 77 is annularly welded as indicated at 82 and 83 to the exterior of this metal housing.

After mounting bracket 77 has been so welded to metal housing 78, the insulating body 79 and the conductors 80 and 81 are assembled loosely with housing 78, as depicted in FIG. 11. But for the preattachment of mounting bracket 77 to metal housing 78, the loose assembly of elements depicted in FIG. 11 corresponds to the loose assembly of similar elements depicted in FIG. 1.

Thereafter the loose assembly shown in FIG. 11 is swaged longitudinally from each end of the assembly toward the center or toward the mounting bracket 77. This results in the final electrical penetrant structure 76 depicted in FIG. 12. Referring to such FIG., the left end portion 84 including the contoured sealing chamber 85 has been swaged, and also the right end portion 86 of the assembly including a contoured sealing chamber 87 has been swaged. This leaves an intermediate unswaged portion 88 immediately under and adjacent mounting bracket 77. The electrical penetrant structure structure 76 may be mounted to a supporting wall (not shown) by securing suitable mounting bracket 77 thereto.

From the foregoing, it will be seen that each of the three preferred forms of the invention illustrated and described includes at least one internal contoured sealing chamber adjacent each end of the electrical penetrant structure. An additional contoured sealing chamber can be provided such as in the case of the form of the invention shown in FIG. 9, for additional sealing if desired. It will also be noted that the resilient insulating material can be continuous from end to end of the metal housing, as in the case of the forms of the invention shown in FIGS. 1–7 and 10–12, or can be interrupted to leave an intermediate gas pressurizing space as in the case of the form of the invention shown in FIGS. 8 and 9.

It will be further noted that in each form of the invention disclosed the body of insulating material extends axially outwardly of the end of the metal housing to provide protection for the wires or conductors as they leave the electrical penetrant structure.

The invention is adaptable to an electrical penetrant structure having one or more conductors. The number of conductors illustrated is not limitative of the invention in this regard. As previously indicated, these conductors can be insulated or not. However, the conductors should be incompressible metal conductors so that no voids will be present after the swaging operation.

It is has been found in actual practice that an electrical penetrant structure constructed in accordance with the principles of the present invention is highly effective in permitting one or more electrical conductors to be fed through a wall in such a manner that a sealed and insulated penetration of this wall is provided. The inventive electrical penetrant structure is particularly advantageous for penetrating the containment vessel wall in a nuclear-powered electrical generating station.

We claim:

1. An electrical penetrant structure, comprising an elongated tubular metal housing, at least one incompressible metal conductor extending through said housing in spaced relation to the surrounding internal wall surface thereof, a portion of said wall surface adjacent each end of said housing being annularly recessed to provide a transversely enlarged internal chamber adjacent each end of said housing, the axial length of each such recessed wall surface portion being at least equal to half the transverse dimension of the exterior of said housing, the outer edge of each of said portions being arranged axially inwardly from the adjacent outer end of said housing a distance at least equal to said transverse dimension, and resilient insulating material compressed between said housing and conductor and transversely filling and axially extending beyond the ends of each of such chambers, said conductor being noncentrally arranged in said insulating material and the portion of said conductor passing through each chamber being laterally offset toward the corresponding recessed wall surface portion.

2. An electrical penetrant structure according to claim 1, wherein said insulating material extends axially outwardly beyond each outer end of said housing.

3. An electrical penetrant structure according to claim 2, wherein axially separated bodies of said insulating material are arranged within said housing to provide a space therebetween, and said housing has a hole in the wall thereof communicating with said space.